

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 9

0217-00088

IN THE MATTER OF:)
)
PHOENIX-GOODYEAR AIRPORT SITE)
)
THE GOODYEAR TIRE & RUBBER)
COMPANY, and LORAL DEFENSE)
SYSTEMS-ARIZONA, A DIVISION OF)
LORAL CORPORATION,)
)
Respondents.)
)
Proceeding under Sections 106)
and 122 of the Comprehensive)
Environmental Response,)
Compensation, and Liability)
Act of 1980, as amended, 42)
U.S.C. Sections 9606 and 9622.)
)

Docket No. 92-05

CONSENT ORDER

I. JURISDICTION

1. This Consent Order is issued pursuant to the authority vested in the President of the United States under Sections 106 and 122 of the Comprehensive Environmental Response, Compensation and Liability Act of 1980, as amended by the Superfund Amendments and Reauthorization Act of 1986, Pub. L. 99-499 ("CERCLA"), 42 U.S.C. Sections 9606 and 9622, as delegated to the Administrator of the Environmental Protection Agency ("EPA") by Executive Order 12580, 52 Fed. Reg. 2923 (1987), and further delegated to the Regional Administrators of EPA by Delegation No. 14-14-C, dated February 26, 1987, and to the Director, Hazardous Waste Management Division, EPA Region 9, by Regional Delegation No. R1290.43,

dated October 26, 1988.

2. The actions required by this Consent Order, if performed in full compliance with the requirements of this Consent Order, are not inconsistent with Part 300 of the National Oil and Hazardous Substances Contingency Plan ("NCP"), 40 C.F.R. Part 300.

3. This Consent Order is entered into voluntarily by EPA, the Goodyear Tire and Rubber Company ("Goodyear"), a corporation incorporated under the laws of the State of Ohio, having its principal place of business at 1144 East Market Street, Akron, Ohio 44316, and Loral Defense Systems-Arizona, a division of Loral Corporation ("Loral"), a corporation incorporated under the laws of the State of New York, having its principal place of business at 600 Third Avenue, New York, New York 10016 (collectively referred to herein as "Respondents"). Respondents agree to undertake all actions and implement all Work required by the terms and conditions of this Consent Order.

4. By entering into this Consent Order, Respondents do not admit the truth of any statements contained in the Findings of Fact or Conclusions of Law except as to jurisdiction, nor do Respondents admit any liability or admit any issues of law or fact or any responsibility for the alleged release or threatened release of any hazardous substances into the environment.

5. EPA has consulted with the State of Arizona in connection with this removal action. Notice of the issuance of this Consent Order has been given to the State of Arizona, as required by Section 106(a) of CERCLA, 42 U.S.C. Section 9606(a).

II. STATEMENT OF PURPOSE

In entering into this Consent Order, the mutual objectives of EPA and Respondents are to conduct the removal activities, as defined in Section 101(23) of CERCLA, 42 U.S.C. Section 9601(23), prescribed herein to abate, mitigate and/or eliminate conditions which may present an imminent and substantial endangerment to the public health or welfare or the environment because of an actual or threatened release of hazardous substances, i.e., chromium and cadmium, at that area south of Yuma Road within the Phoenix-Goodyear Airport Superfund Site (South), as shown on the map annexed hereto as Attachment 1 (hereinafter the "Site"). More specifically, the removal activities to be conducted pursuant to this Consent Order will be conducted at and around the so-called "Chrome Sludge Drying Beds" located on the Site, as shown on Attachment 1. The Chrome Sludge Drying Beds, consisting of Chrome Sludge Drying Bed No. 1 and Chrome Sludge Drying Bed No. 2 are shown in greater detail on Attachment 2.

III. FINDINGS OF FACT

Based on available information, including the Administrative Record in this matter, EPA hereby finds:

1. Respondent Goodyear is the successor-in-interest to Goodyear Aerospace Corporation ("GAC"), the former owner and operator of a manufacturing facility at the Site. Respondent Loral is the present owner of the Chrome Sludge Drying Beds at the Site.

2. Major operations at the GAC facility included the manufacture of electronic equipment, transparent products, structural equipment and aluminum shelters. One of the activities associated with these operations was chrome plating.

3. The major waste streams generated by GAC at the Site were waste solvents, chromate sludge from the chrome-plating operations, acids, processed wastewaters and domestic sewage. Treated wastes from anodizing, metal etching, plating, and plastics polishing were disposed of in the Chrome Sludge Drying Beds until about 1976 and until about 1980 in a third chrome sludge drying bed located adjacent to Chrome Sludge Drying Bed No. 2 (which was incorporated into Chrome Sludge Drying Bed No. 2 during the soil investigations described below).

4. Chromium was also detected in certain soil borings taken at and around the Chrome Sludge Drying Beds. These samples were taken by GAC and reported to EPA in the report entitled Evaluation of Soils and Shallow Groundwater Contamination, dated May 1985. Laboratory analysis of such sampling showed the presence of chromium at Chrome Sludge Drying Bed No. 2 up to a concentra-

tion of 3,400 parts per million (ppm). Additional soil samples taken at Chrome Sludge Drying Bed No. 2 by EPA in 1987 showed chromium levels up to 32,500 ppm. According to the Technical Memorandum entitled Soil Sampling at the GAC Chrome Sludge Drying Beds (ICF, November 1988) ("Technical Memorandum"), concentrations of chromium in the soil at Chrome Sludge Drying Bed No. 2 were found to be as high as 27,843 ppm. Concentrations of chromium at Chrome Sludge Drying Bed No. 1 were found to be as high as 525 ppm. By comparison, the background level of chromium at the Site is approximately 30 ppm.

5. According to the Technical Memorandum, concentrations of cadmium in the soil were found to be as high as 23 ppm at Chrome Sludge Drying Bed No. 1 and 112 ppm at Chrome Sludge Drying Bed No. 2. By comparison, the background level of cadmium at the Site is approximately 1.2 ppm.

6. Chromium was also found in the Subunit A groundwater samples underlying the Chrome Sludge Drying Beds at levels up to 1,340 ppb. The Subunit A groundwater treatment plant (Section 16 Operable Unit), constructed pursuant to the Record of Decision executed on September 25, 1987 by the Regional Administrator of EPA Region 9 ("1987 ROD"), and the Subunit B/C groundwater treatment plant to be constructed pursuant to the 1989 ROD (defined

below), are responsible for ensuring that metal contamination, including chromium and cadmium, in the groundwater at the Site is cleaned up to 50 ppb and 10 ppb, respectively.

7. Pursuant to Consent Order 88-21, issued by EPA on September 30, 1988, Respondent Goodyear conducted a Feasibility Study analyzing a potential response action to eliminate the threat to public health and the environment posed by the Chrome Sludge Drying Beds. Response alternatives evaluated in the Feasibility Study, dated February 16, 1989, included excavation, soil washing, stabilization, vitrification, surface covers, and the "no action" alternative.

8. The initial soil investigations at the Chrome Sludge Drying Beds were conducted as part of the broader remedial action to be implemented at the Site, which was placed on the National Priorities List in 1983, 48 Fed. Reg. 40658. Several of the studies and reports produced as part of the Remedial Investigation/Feasibility Study ("RI/FS"), dated June 1989, at the Site also addressed the chromium and cadmium contamination at and adjacent to the areas surrounding the Chrome Sludge Drying Beds. However, EPA deferred addressing the remediation of the contaminated soils at the Chrome Sludge Drying Beds as part of the remedial action and addressed this area separately. Consent Order 88-21 required the contamination at the Chrome Sludge Drying Beds to be further studied and analyzed independently from

the RI/FS. The Feasibility Study produced pursuant to Consent Order 88-21 embodied the results of that analysis. The selected final remedial action, set forth in a final Record of Decision executed on September 26, 1989 by the Regional Administrator of EPA Region 9 ("1989 ROD"), addressed the remaining soil contamination (other than the chromium and cadmium contamination at the Chrome Sludge Drying Beds) and the groundwater contamination in Subunit B/C. Groundwater contamination in Subunit A was addressed by the 1987 ROD. On May 7, 1991, the United States Department of Justice lodged with the United States District Court for the District of Arizona the Consent Decree for the final remedy at the Site (Civ. Action No. 88-1443 PHX EHC) executed by the United States, the State of Arizona, Goodyear and Loral to implement the 1989 ROD (the "Consent Decree").

9. In connection with the remedial activities undertaken at the Site, a formal community relations plan ("CRP") was prepared after conducting interviews with local officials, residents and other interested persons. In addition, a local information repository concerning the Site was established in connection with the remedial action, and has been expanded to include the chromium sludge bed response action. All persons on the community relations mailing list were sent notice of the public availability of the administrative record for the chromium sludge bed response action.

10. This removal action will contribute to the efficient performance of the long-term remedial action to be undertaken pursuant to the Consent Decree.

11. Due to the fact that EPA has determined that a planning period of at least six (6) months exists prior to the initiation of the on-site removal activity, i.e., that this is a non-time critical removal, an Engineering Evaluation/Cost Analyses ("EE/CA") or its equivalent, is required by the NCP. EPA has determined that the Feasibility Study, comments and responses thereto contained in the Administrative Record for this removal and the Chromium Response Action Work Plan, dated June 7, 1991, which was revised and redated October 11, 1991 (as revised, the "Work Plan"), constitute an EE/CA equivalent document for purposes of this removal action.

12. By the Work Plan, Respondent Goodyear proposed to remediate the area surrounding Chrome Sludge Drying Bed No. 2 by excavating soils contaminated with chromium and cadmium beyond the draft Arizona Human Health Based Guidance Levels For Contaminants in Drinking Water and Soil, dated September 18, 1990 (the "draft Guidance Levels"), and stabilizing the contaminated soils into larger sized particles. Goodyear proposed to place cover materials over the stabilized mass, and committed to ensure that the resulting stabilized mass and all replaced soil (to be used as cover material) will prevent the formation of leachate in

excess of the Toxicity Characteristic Leaching Procedure Test ("TCLP"), in conformity with the Resource Conservation and Recovery Act ("RCRA") Land Disposal Restrictions, 40 C.F.R. Part 268. No soils surrounding Chrome Sludge Drying Bed No. 1 were found to contain contamination above the draft Guidance Levels, and therefore, no response action was proposed for the soils at Chrome Sludge Drying Bed No. 1.

13. By public notice dated June 27, 1991, EPA informed the public of the availability of the Administrative Record and the EE/CA equivalent document for this removal action at the information repository referred to above, and specifically informed the public of its intention, based on the information contained in the Administrative Record to that date, to approve the work detailed in the June 7, 1991 Work Plan submitted by Goodyear as the appropriate response. The notice opened a thirty (30) day public comment period, which ended on July 30, 1991. Loral submitted two comments, and appropriate changes were incorporated into the June 7, 1991 Work Plan, which was revised and redated to October 11, 1991. By Action Memorandum dated October 15, 1991 (the "Action Memorandum"), the Director of the Hazardous Waste Management Division of EPA Region 9, approved the proposed response action for the contaminated soil at and around areas adjacent to Chrome Sludge Drying Bed No. 2.

IV. CONCLUSIONS OF LAW

1. The Site is a "facility" as defined by Section 101(9) of CERCLA, 42 U.S.C. Section 9601(9).
2. Each Respondent is a "person" as defined in Section 101(21) of CERCLA, 42 U.S.C. Section 9601(21).
3. Respondents are past and present owners and operators of the facility, and are therefore potentially responsible parties under Section 107(a) of CERCLA, 42 U.S.C. Section 9607(a).
4. Chromium and cadmium are hazardous substances, as defined in Section 101(14) of CERCLA, 42 U.S.C. Section 9601(14).
5. The presence of these hazardous substances at the Site and the migration and/or potential migration of these hazardous substances from the Site constitutes an actual and/or threatened "release" as that term is defined in Section 101(22) of CERCLA, 42 U.S.C. Section 9601(22).
6. Respondents are jointly and severally liable for conducting the actions ordered herein.

V. DETERMINATIONS

Based on the Findings of Fact and Conclusions of Law set forth above, the Director, Hazardous Waste Management Division, EPA Region 9, has determined that:

1. The actual or threatened release of hazardous substances from the Site may present an imminent and substantial endangerment to the public health, welfare or the environment.

2. The actions required by this Consent Order are reasonable and necessary to protect the public health, welfare and the environment because of the high levels of hazardous substances, i.e., chromium and cadmium, in soils at or near the surface that may migrate through the ingestion, inhalation and groundwater pathways.

VI. PARTIES BOUND

1. This Consent Order shall apply to and be binding on Respondents, their officers, directors, employees, agents, successors and assigns.

2. No change in ownership or corporate or partnership status will in any way alter Respondents' responsibilities under this Consent Order.

3. Respondents shall provide a copy of this Consent Order to any successors or assigns before ownership rights are transferred.

4. Respondents and any successors or assigns shall offer, and upon request provide, a copy of this Consent Order to each and every contractor, subcontractor and consultant retained to conduct any portion of the Work to be performed pursuant to this Consent Order, and shall condition any contract for the Work on compliance with this Consent Order.

5. The signatories to this Consent Order certify that they are fully authorized to enter into the terms and conditions of this Consent Order and to execute and legally bind the parties they represent to this Consent Order.

VII. WORK TO BE PERFORMED

1. Respondents shall perform all work necessary to implement the removal action as defined by the Action Memorandum and further defined by this Consent Order and the Work Plan (the "Work"). The Action Memorandum is hereby incorporated into this Consent Order. All Work shall be performed by qualified employees or contractors of Respondents in accordance with Subparagraphs 2, 3, and 4 of this Section. Respondents' selection of any prime contractor shall be subject to EPA approval. If at any time thereafter Respondents propose to change their prime contractor, Respondents shall give written notice to EPA and shall obtain approval from EPA before the new prime contractor performs any Work under this Consent Order. Respondents remain responsible to fully carry out the Work described in this Section and achieve any performance standard required by the Work. Nothing in this Consent Order, or in EPA approval of Respondents' prime contractor or submissions, shall be deemed to constitute a warranty or representation of any kind by EPA of full performance of the Work.

2. Requirements of the Work.

a. The Work shall consist of:

(i) preparation of a "PGA Chromium Response Action Workplan" (hereinbefore defined as the "Work Plan");

(ii) design, implementation, reporting, monitoring and maintenance of the Work as described in the Work Plan (including the Contractor's Implementation Plan; the Final Report; and the Inspection Plan); the Action Memorandum and this Consent Order.

b. Work Plan.

(i) EPA hereby approves the October 11, 1991 Work Plan, attached hereto as Attachment 3, except as to the following, which Respondents hereby agree to add to and incorporate in the Work Plan:

A) Contractor's Implementation Plan;

B) Final Report;

C) Inspection Plan.

c. Contractor's Implementation Plan.

The Contractor's Implementation Plan ("Implementation Plan") shall consist of a detailed description of all activities needed for the implementation of the Work. The Implementation Plan must also include a Field Sampling Plan pursuant to Section X (Quality Assurance/Quality Control), a Quality Assurance/Quality Control Project Plan pursuant to Section X

(Quality Assurance/Quality Control), and a Worker Health and Safety Plan pursuant to Section IX (Worker Health and Safety Plan). The Implementation Plan also must include a description of bench scale or pilot tests (if any) and a description of runoff control and erosion control measures to be constructed.

d. Final Report.

The Final Report ("Final Report") shall consist of a narrative summary of the Work completed, final chromium and cadmium contour maps for Chrome Sludge Drying Bed No. 2 and the adjacent areas, a description of the total volume of soil excavated and total volume stabilized, a map identifying the specific locations (both horizontal and vertical) of the stabilized product and cover materials, and a summary of all data generated, along with copies of all laboratory reports, pursuant to the sampling and analysis carried out under this Consent Order. The Final Report shall also describe any issues, problems, or deficiencies encountered in implementing the Work.

e. Inspection Plan.

The Inspection Plan ("Inspection Plan") shall include a detailed description of closure and post-closure activities to be undertaken to assure the long term integrity of the Work. The Inspection Plan shall include, but not be limited to, the following:

i) a description of the frequency and scope of routine inspections of the physical integrity of the Work;

ii) a description of the routine groundwater monitoring plan for chromium and cadmium, which shall be performed on the same schedule and in conjunction with the monitoring program for the Operable Unit Remedy for Subunit A, as required by the Consent Decree for the final remedy at the Site;

iii) a description of the frequency and scope of routine inspections of the erosion and run-off control measures to be taken;

iv) a description of the routine inspections that will take place to ensure that land use activities at or near the Site do not threaten the physical integrity of the Work;

v) a description of corrective action required to be undertaken by current and future owners of the Site should the physical integrity of the Work and/or run-off and erosion control measures become impaired and/or should groundwater monitoring indicate infiltration of chromium and/or cadmium to the Subunit A groundwater.

f. Performance Standards.

Respondents shall ensure that in the performance of the Work the following standards shall be met:

(i) All soils at and adjacent to Chrome Sludge Drying Bed No. 2 (including soils under the pond located at the southwest corner of Chrome Sludge Drying Bed No. 2) containing more than 2,000 ppm total chromium or 100 ppm cadmium will be excavated and stabilized. The stabilization process shall be sufficient to:

(A) upon placement, prevent the formation of leachate in excess of the limits prescribed by 40 C.F.R. Part 268, the RCRA Land Disposal Restrictions; i.e., 5.2 ppm for chromium and .066 ppm for cadmium; and

(B) upon commencement of on-site excavation activities pursuant to this Consent Order (i.e., utility encasement), prevent the suspension of dusts containing chromium and cadmium in excess of 2,000 ppm for chromium and 100 ppm for cadmium; and

(C) upon placement, ensure that the particle sizes of the stabilized soils will withstand normal weathering and abrasion forces, i.e.; that after a prescribed tumbling time, at least ninety percent (90%) of the particles will exceed the diameter of fifty (50) microns.

3. Schedule of the Work

a. Within thirty (30) days after the effective date of this Consent Order, Respondents shall complete and submit to EPA the final removal action contractor bid request specifications for the implementation of the Work.

b. Within sixty (60) days after EPA submission of comments on the bid request specifications, Respondents shall (1) select a contractor to implement the Work and (2) submit to EPA for review, comment and approval the Implementation Plan as defined in Subparagraph c. of this Section.

c. Within ninety (90) working days (i.e., excluding Saturdays, Sundays and federal holidays) after EPA approval of the Implementation Plan, Respondents shall complete site mapping and implementation of the Work in a satisfactory manner, including all excavation, stabilization, placing of cover materials and grading, per the specifications set forth in the Work Plan.

d. Within one-hundred thirty-five (135) working days after EPA approval of the Implementation Plan, Respondents shall submit a (1) Final Report and an (2) Inspection Plan as defined in Subparagraphs d. and e. of this Section for review, comment and approval by EPA.

e. Upon EPA approval of the Inspection Plan, Respondents shall carry out the Inspection Plan.

4. Upon Respondents' completion of the activities required in Subparagraphs 1, 2, and 3 above, Respondents shall submit to EPA a letter certifying that they have completed all such activities. The certification shall be by authorized officials of Respondents in the following form:

"I certify that the information contained in or accompanying this letter is true, accurate and complete."

Signature

Title

VIII. DESIGNATED PROJECT COORDINATOR

1. On or before the effective date of this Consent Order, Respondents shall designate one Project Coordinator to represent them. Respondents shall notify EPA in writing of the name, address and telephone number of their Project Coordinator, and any successors. EPA has designated Craig Cooper of the EPA Region 9 Superfund Enforcement Branch, Enforcement Programs Section as its Project Coordinator. The EPA Project Coordinator shall have the authority vested in the Remedial Project Manager and the On-Scene Coordinator by 40 C.F.R. Section 300 et seq., as the same may from time to time be amended, including the authority to halt, conduct, or direct any Work required by this Consent Order, or to direct any other response action undertaken by EPA or Respondents at the Site and to ensure that the Work is performed in accordance with all applicable statutes, regulations and this Consent

Order. The EPA Project Coordinator shall also have the authority to require a cessation of the performance of the Work or any other activity at the Site that, in the opinion of the EPA Project Coordinator, may present or contribute to an endangerment to public health, welfare, or the environment or cause or threaten to cause the release of hazardous substances from the Site. In the event the EPA Project Coordinator suspends the Work or any other activity at the Site, the parties may extend the compliance schedule of this Consent Order as appropriate for the minimum period of time necessary to perform the Work, but in no event for a period longer than the time of the suspension of Work or other activities. Should Respondents desire to extend the compliance schedule pursuant to this Subparagraph 1, Respondents shall propose and EPA shall determine the length of any extension. If the EPA Project Coordinator suspends the Work or any other activity for any of the reasons set forth in this Subparagraph 1 and those reasons are due to acts or omissions of Respondents or their contractors not required by this Consent Order, then any extension of the compliance schedule shall be at EPA's discretion. The Project Coordinators do not have the authority to modify in any way the terms of this Consent Order. The absence of the EPA Project Coordinator from the Site shall not be cause for the stoppage of the Work. EPA and Respondents

shall each have the right to change their respective designated Project Coordinator by notifying the other parties in writing at least seven (7) days prior to the change.

2. Respondents' Project Coordinator shall be responsible for coordinating and overseeing Respondents' performance under this Consent Order. To the maximum extent possible, communications between Respondents and EPA concerning the activities to be performed pursuant to the terms and conditions of this Consent Order, and all documents, reports, approvals and other correspondence concerning activities relevant to this Consent Order, shall be directed through the Project Coordinators. During the implementation of the Work, the Project Coordinators shall, whenever possible, operate by consensus, and shall attempt in good faith to resolve disputes informally through discussion of the issues.

3. Respondents' Project Coordinator may assign other representatives, including other contractors, to serve as a Site representative for oversight of performance of daily operations during removal activities.

4. The EPA Project Coordinator may assign other representatives, including other EPA employees or contractors, to serve as a Site representative for oversight of performance of daily operations during removal activities. Prior to invoking formal

dispute resolution procedures, any unresolved technical disputes arising between EPA and Respondents or their contractors shall be referred to the EPA Project Coordinator.

IX. WORKER HEALTH AND SAFETY PLAN

The Worker Health and Safety Plan that Respondents are required to submit pursuant to Section VII (Work to be Performed) of this Consent Order shall satisfy all applicable requirements of the Occupational Safety and Health Act of 1970, as amended, including the requirements of the Occupational Safety and Health Administration (OSHA) regulations applicable to Hazardous Waste Operations and Emergency Response, 29 C.F.R. Part 1910 and the Occupational Safety and Health Guidance for Hazardous Waste Site Activities (October 1985 (DHH 5 NIOSH) Publication No. 85-115), as well as EPA's Standard Operating Safety Guides (EPA, OERR November 1984), and amendments thereto.

X. QUALITY ASSURANCE/QUALITY CONTROL

1. The Quality Assurance/Quality Control Project Plan ("QA/QC Plan") that Respondents are required to submit pursuant to Section VII (Work to be Performed) of this Consent Order shall be prepared in accordance with current EPA guidance, "Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans," dated February 1983, QAMS-005/80, "Data Quality Objective Guidance," (EPA/540/G87/003 and 004), and any amendments or updates to such guidelines.

2. Respondents shall utilize QA/QC procedures in accordance with the QA/QC Plan submitted pursuant to this Consent Order, and shall utilize standard EPA chain of custody procedures, as set forth in the "EPA NEIC Policies and Procedures Manual," dated May 1978, revised May 1986, EPA Document 330/9-78-001-R, and amendments thereto; the "National Enforcement Investigations Center Manual for the Evidence Audit," published in September 1981, and amendments thereto, the "U.S. EPA Region 9 Guidance for Preparing Quality Assurance Project Plans for Superfund Remedial Projects," dated September 1989, 9QA-03-89, and any EPA updates or revisions thereto, for all sample collection and analysis activities. In order to provide quality assurance and maintain quality control regarding all samples collected pursuant to this Consent Order, Respondents shall:

a. Ensure that all contracts with laboratories utilized by Respondents for analysis of samples taken pursuant to this Consent Decree provide for access of EPA personnel and EPA authorized representatives to assure the accuracy of laboratory results related to the work.

b. Ensure that laboratories utilized by Respondents for analysis of samples taken pursuant to this Consent Order perform all analyses according to EPA methods or methods deemed in advance satisfactory by EPA. Accepted EPA methods are documented in the "Contract Lab Program Statement of Work for Inorganic

Analysis," dated July 1988, and any EPA updates or revisions thereto. TCLP testing shall be carried out in accordance with "Tests for Evaluating Solid Wastes, Physical/Chemical Methods," EPA Publication No. SW-846.

c. Ensure that all laboratories utilized by Respondents for analysis of samples taken pursuant to this Consent Order participate in an EPA or EPA equivalent QA/QC program. As part of the QA/QC program and upon request by EPA, such laboratories shall, at Respondents' expense, perform analysis of samples provided by EPA to demonstrate the quality of each laboratory's data. EPA may provide to each laboratory a maximum of four (4) samples per year per analytical combination.

2. The Field Sampling Plan that Respondents are required to submit pursuant to Section VII (Work to be Performed) of this Consent Order shall be prepared in accordance with "Preparation of a U.S. EPA Region 9 Field Sampling Plan for Private and State-Lead Superfund Projects," April 1990, DCN 9QA-06-89. The Field Sampling Plan shall be submitted for EPA approval prior to the commencement of any sampling or monitoring activities pursuant to this Consent Order. Respondents shall provide EPA with notice of any planned sample collection and analysis activities required by this Consent Order at least five (5) days prior to the planned sample collection activity.

3. Employees of EPA and its authorized representatives shall have the right, upon request, to take splits of any samples obtained by Respondents or anyone acting on Respondents' behalf in the implementation of the Work. Respondents shall notify EPA no less than seven (7) working days in advance of any sample collection activities. In addition, EPA shall have the right to take any additional samples that EPA deems necessary. Respondents shall also have the right upon request to obtain splits of samples taken independently by EPA and its authorized representatives.

4. Any analytical or design data generated or obtained by Respondents that are related to the Work shall be provided to EPA within seven (7) days of any request by EPA for such data.

XI. REPORTING AND APPROVALS/DISAPPROVALS

A. Progress Reports

1. Beginning on the tenth (10th) day of the second month following the month in which this Consent Order becomes effective, Respondents shall submit to EPA monthly reports describing (a) all actions taken to comply with this Consent Order, including a general description of the Work activities commenced or completed during the previous reporting period; (b) the results of all sampling, testing, and other data generated by Respondents during the previous reporting period; (c) all activities projected to be commenced or completed during the next reporting

period; and (d) any problems that were encountered or are anticipated by Respondents in commencing or completing the Work activities and a description of efforts made to mitigate any problems or potential delays. Upon EPA approval of the Inspection Plan, the progress reports required by this Section shall be submitted annually. These progress reports shall be submitted to EPA by the tenth (10th) of each month for work done during the preceding month or year, as the case may be, and may be consolidated with other routine reports Respondents submit to EPA, including reports submitted pursuant Section VIII (Reporting and Approvals/Disapprovals) to the Consent Decree for the final remedy at the Site. In addition, EPA may request periodic briefings by Respondents to discuss the progress of the Work.

B. Reports, Plans, and Other Items

1. Any reports, plans, specifications (including discharge or emission limits), schedules, appendices and attachments required to be submitted to EPA by this Consent Order are, upon approval by EPA, incorporated into this Consent Order. Any non-compliance with such EPA approved reports, plans, specifications, schedules, or other submissions shall be considered non-compliance with the requirements of this Consent Order.

2. If EPA disapproves any plans or reports (other than progress reports), or other items required to be submitted to EPA for approval pursuant to this Consent Order, Respondents shall

correct any deficiencies and resubmit the plan, report or item for EPA approval. Such plan, report or item shall be postmarked within fifteen (15) working days from Respondents' receipt of EPA disapproval.

3. Any disapprovals by EPA shall be in writing and shall include an explanation by EPA of why the plan, report, or item is being disapproved.

4. In attempting to correct any deficiency as required by Subparagraph B.2, Respondents shall address each of EPA's comments and resubmit to EPA the corrected plan, report or item with the required changes within the fifteen (15) day deadline except that the period for Respondents' response may be extended by EPA, at its discretion.

5. If EPA determines that any plan, report, or item is substantively deficient after resubmission, then Respondents shall be deemed to be in violation of this Consent Order and subject to stipulated penalties as governed by Section XXI of this Consent Order. In the event that the deficiency in the plan, report or other item is corrected by one subsequent resubmission permitted under this Subparagraph B.2 - B.4, then Respondents shall not be deemed to be in violation of this Consent Order.

XII. SUBMISSION OF DOCUMENTS

1. Respondents shall provide to EPA two (2) copies of all deliverables specifically required to be provided by this Consent Order. Respondents shall provide to EPA upon request copies of all charts, maps, letters, memoranda, invoices, shipping manifests, reports, logs, data or other records or documents relevant to the performance of Work under this Consent Order, or which are required to be provided to EPA by CERCLA, RCRA, or any other applicable law.

2. When notification to or communication with EPA, Respondents is required by the terms of this Consent Order, it shall be in writing, postage prepaid, and addressed as follows:

As to EPA:

Craig Cooper
EPA Project Coordinator - PGA Site (Removal)
Superfund Enforcement Branch (H-7-2)
U.S. Environmental Protection Agency
75 Hawthorne Street
San Francisco, CA 94105

As to Respondents:

Edward P. Waltz
The Goodyear Tire & Rubber Company
Project Manager -- PGA Site
Corporate Environmental Engineering
1144 East Market Street
Akron, OH 44316

Loral Defense Systems - Arizona
James F. Price
P.O. Box 85
Litchfield Park, Arizona 85340-0085

Any submission to EPA for approval pursuant to this Consent Order shall be made to the address shown above and shall be made by overnight mail or some equivalent delivery service.

3. Respondents agree to provide a copy of the Work Plan, the bid request specifications, the Contractor's Implementation Plan, the Final Report and the Inspection Plan, and any revisions thereto, to the State of Arizona Project Manager -- PGA Site, Arizona Department of Environmental Quality, 2005 North Central Avenue, Phoenix, Arizona, 85004. Failure of Respondents to comply with the foregoing shall not provide a basis for the imposition of stipulated penalties under this Consent Order.

4. No informal advice, guidance, suggestions, or comments by EPA regarding reports, plans, specifications, schedules, or other submissions by Respondents shall be construed as relieving Respondents of their obligation to obtain such formal approval as may be required by this Consent Order.

5. All data, factual information, and documents submitted by Respondents to EPA pursuant to this Consent Order shall be subject to public inspection unless Respondents assert a confidential business information or trade secret claim for each submission to EPA as described in this Subparagraph. Respondents shall not assert a claim of confidentiality regarding any hydrogeologic or geologic data, groundwater monitoring data, data relating to disposal activities, or any other data, information,

or documents that are not entitled to protection under Section 104(e)(7)(F) of CERCLA, 42 U.S.C. Section 9607(e)(7)(F) and 40 C.F.R. Part 2. Respondents may assert a claim of business confidentiality as to all or part of any process, method, technique, or any description thereof provided by Respondents in connection with this Consent Order that Respondents claim constitute proprietary or trade secret information developed by Respondents or developed by their contractor or contractor's subcontractors, in accordance with 40 C.F.R. Section 2.203. In addition, Respondents may assert business confidentiality claims covering part or all of the information provided in connection with this Consent Order only as provided for by Section 104(e)(7) of CERCLA, 42 U.S.C. Section 9607(e)(7), and pursuant to 40 C.F.R. Section 2.203(b). Any such claim shall be subject to EPA's confidentiality determination procedures and, if determined by EPA to be confidential, afforded the protection by EPA provided in 40 C.F.R. Part 2, Subpart B.

6. The provisions of this Section shall not constitute a waiver of any applicable claims of attorney work product or any other privilege under law. If Respondents assert any such privilege, Respondents' shall, upon request, provide EPA with an identification of the title and subject matter of each document for which a privilege is asserted, and an explanation as to why the privilege is applicable to the document or portions thereof.

XIII. SITE ACCESS

1. Respondents shall provide EPA and its authorized representatives, including contractors, access at all reasonable times to the Site and any contiguous property owned by or to the extent access to the property is controlled by or available to Respondents. EPA shall endeavor to provide reasonable notice prior to requesting access to the property. EPA and its authorized representatives shall comply with all applicable provisions of the Worker Health and Safety Plan submitted pursuant to Section VII (Work to Be Performed) and Section IX (Worker Health and Safety Plan) of this Consent Order and approved by EPA, and shall comply with all applicable provisions of federal law and security requirements.

2. Within sixty (60) days after the effective date of this Consent Order, any Respondent who owns any interest in the Site, shall (1) ensure that a copy of this Consent Order and the approved Inspection Plan is provided to any subsequent purchaser of the property prior to sale, and (2) record notation on each deed, title, or other instrument of conveyance for the Site or portions thereof stating that the property is subject to this Consent Order, including the Inspection Plan.

3. The obligations under this Section of the Consent Order of each Respondent who owns any interest in the Site, shall run with the land and shall be binding upon any and all such

Respondent(s) and any and all persons who subsequently acquire any such interest or portion thereof (hereinafter "successors-in-title"). Within ten (10) days after the effective date of this Consent Order, each Respondent who owns any interest in the Site shall record at the Registry of Deeds, or other office where land ownership and transfer records are maintained for the property, a notice of obligation to provide access and related covenants. Each subsequent deed to any such property included in the Site shall reference the recorded location of such notice and covenant applicable to the property.

4. Any Respondent that owns an interest in the Site and any successor-in-title shall, prior to the conveyance of any such interest, give written notice of this Consent Order to the grantee and written notice to EPA of the proposed conveyance, the name and address of the grantee, and the date on which notice of the Consent Order was given to the grantee. In the event of any such conveyance, Respondents' obligations under this Consent Order shall continue to be met by all Respondents and, subject to approval by EPA, by the grantee.

5. Access shall be for purposes of conducting any activity authorized by this Consent Order, including, but not limited to:

- a. Monitoring the Work or any other activities taking place;
- b. Verifying any data or information submitted to EPA;

- c. Conducting investigations relating to contamination at or near the Site;
- d. Obtaining samples at or near the Site; and
- e. Inspecting and copying records, operating logs, contracts, or other documents maintained or generated by Respondents or their representatives to assess Respondents' compliance with this Consent Order.

7. Notwithstanding any provision of this Consent Order, EPA retains all of its access authorities and rights under CERCLA, RCRA, and any other applicable statutes, regulations or permits.

8. Respondents shall be responsible for any claims arising from activities conducted by Respondents, their representatives and consultants on third-party property in connection with this Consent Order.

XIV. ENDANGERMENT AND EMERGENCY RESPONSE

In the event of any action or occurrence during the performance of the Work which causes or threatens a release of hazardous substances greater than reportable quantities as defined in Section 103 of CERCLA, or which may present an immediate threat to public health or welfare or the environment, Respondents shall immediately take all appropriate action to prevent, abate, or minimize such release or endangerment, and shall immediately notify EPA's Project Coordinator, or, if the Project Coordinator is unavailable, Respondents shall notify the Emergency Response

Unit, EPA Region IX. Respondents shall take such response action in accordance with all applicable provisions of the Work required by this Consent Order. In the event that Respondents fail to take appropriate response action as required by this Section, and EPA takes such action instead, Respondents shall reimburse EPA all costs of the response action that are incurred in a manner not inconsistent with the NCP. Payment of such costs of response shall be made in the manner described in Section XXVII (Reimbursement of Future Response and Oversight Costs) within sixty (60) days of Respondents' receipt of demand for payment.

XV. RECORD PRESERVATION

1. Respondents shall preserve and retain all records and documents now in their possession or control or in the possession or control of their divisions, employees, or contractors that relate in any manner to the Site, regardless of any document retention policy to the contrary, for no less than six (6) years after the termination of this Consent Order.

2. Until termination of this Consent Order, Respondents shall preserve, and shall instruct the contractor, any contractor's subcontractors, and anyone else acting on Respondents' behalf at the Site to preserve (in the form of originals or exact copies, or in the alternative, microfiche of all originals) all records, documents and information of whatever kind, nature or description relating to the performance of Work

at the Site. After this six (6) year period, Respondents shall notify EPA at least thirty (30) days prior to the destruction of such documents. Upon request of EPA, Respondents shall make available to EPA originals or copies of such records prior to their destruction.

XVI. RESERVATION OF RIGHTS

1. EPA expressly reserves all rights and defenses that it may have, including the right to disapprove of Work performed by Respondents under this Consent Order, to require additional response activities if necessary to implement the Work, to perform any response activities that Respondents fail to perform, to take enforcement action for violations of this Consent Order, and to take any enforcement action pursuant to CERCLA and/or any other authority.

2. The parties recognize that Respondents are entering into this Consent Order as a compromise of disputed claims and that Respondents do not admit, accept or intend to acknowledge any liability or fault with respect to any matter arising out of or relating to the Site. Respondents retain the right to controvert the validity of any factual or legal claims or determinations made herein by EPA, except that Respondents will not contest (1) EPA's jurisdiction to issue or enforce the Consent Order in any proceeding to enforce the Consent Order, (2) the issuance of this Consent Order, and Respondents agree to be bound by its terms.

3. Respondents hereby release and covenant not to sue, in either an administrative or judicial forum, EPA and its officers, administrators and representatives and the Hazardous Substances Superfund, for any claim, counter-claim, or cross-claim that was asserted or could have been asserted prior to the effective date of this Consent Order arising out of or relating to the Site. Respondents reserve all rights and defenses to assert claims against any other potentially responsible parties ("PRPs") which are not signatories to this Consent Order with respect to any agreements relating to performance of the Work under this Consent Order.

4. EPA reserves its right to request that Respondents perform response actions in addition to those required by this Consent Order, if EPA determines that such actions are necessary. In the event that Respondents decline to perform such additional actions, EPA reserves the right to undertake such actions and to seek reimbursement from Respondents for such costs. The rights reserved by EPA include, but are not limited to, the right to seek monetary penalties or other relief for any violation of law or this Consent Order; the right to issue additional Orders under Section 106(a) of CERCLA, 42 U.S.C. Section 9606(a); to take necessary response action under Section 104(a) of CERCLA, 42 U.S.C. Section 9604(a); and to bring a civil action under Section

106(a) of CERCLA, 42 U.S.C. Section 9606(a) and/or Section 107 of CERCLA, 42 U.S.C. Section 9607, against Respondents or other parties regarding this Site.

5. Notwithstanding compliance with the terms of this Consent Order, Respondents are not released from liability, if any, for any actions beyond the terms of this Consent Order.

6. Nothing in this Consent Order shall be deemed to limit the response authority of EPA under Section 104 of CERCLA, 42 U.S.C. Section 9604, under Section 106 of CERCLA, 42 U.S.C. Section 9606, or under any other federal response authority. In the event EPA exercises such response authority, EPA reserves the right to seek reimbursement from Respondents for such costs incurred by EPA.

XVII. INDEMNIFICATION

Respondents shall indemnify EPA and hold EPA harmless for any claims arising from any injuries or damages to persons or property resulting from any acts or omissions of Respondents, their officers, directors, employees, agents, receivers, trustees, successors, assigns, contractors, subcontractors, or any other person acting on their behalf or under their control in carrying out this Consent Order. For purposes of this Consent Order, EPA and its contractors are not parties to any contract entered into by Respondents.

XVIII. NOTIFICATION OF DELAY

1. Respondents shall notify EPA of any delay or anticipated delay in achieving compliance with any requirement of this Consent Order. Such notification shall be made verbally to EPA's Project Coordinator no later than two (2) working days after Respondents become aware of such delay or anticipated delay and in writing no later than twelve (12) days after oral notification is due under this subparagraph. The written notification shall describe fully the nature of the delay, the reasons the delay is beyond the control of Respondents, the actions that will be taken to mitigate, prevent and/or minimize further delay, the anticipated length of the delay and the timetable according to which the actions to mitigate, prevent and/or minimize the delay will be taken. Respondents shall adopt all reasonable measures to avoid or minimize such delay.

XVIX. DISPUTE RESOLUTION

1. The parties to this Consent Order shall attempt to resolve expeditiously and informally any disagreements concerning implementation of this Consent Order (including the approval or disapproval of submittals) or any Work required hereunder. If the parties fail to expeditiously resolve such dispute informally, any party desiring dispute resolution under this Section shall, consistent with the requirements of Subsection 2 below, promptly give written notice to the other parties.

2. If Respondents object to any EPA decision regarding the implementation of this Consent Order (including the approval or disapproval of submittals) or any Work required hereunder, Respondents shall notify EPA in writing of their objections within fourteen (14) calendar days of notification of EPA's decision. If EPA objects to Respondents' performance of any of its obligations under this Consent Order, EPA shall promptly notify Respondents in writing of its objections. The parties' notification shall set forth the issues in dispute, the relevant facts upon which the dispute is based, and factual data, analysis or opinion supporting their position, and all supporting documentation relied on in support of that parties' position (hereinafter "Statement of Position"). In the event that this time period of fourteen (14) days may cause a delay in the Work, EPA may shorten the time period for Respondents' submittal of its Statement of Position by setting forth a shorter period in which to respond to EPA's decision. The parties' will then have an additional fourteen (14) calendar days from receipt of the other parties' Statement of Position to reach agreement through informal negotiations. If no agreement is reached, the Director, Hazardous Waste Management Division, Region 9 will resolve the dispute consistent with the NCP and the terms of this Consent Order. Respondents shall then implement EPA's decision.

3. Use of this dispute resolution provision does not relieve Respondents from their duty to timely complete all other tasks required by this Consent Order in accordance with the schedule set forth herein. Respondents' decision to invoke dispute resolution shall not constitute a Force Majeure under Section XX (Force Majeure) herein. Stipulated penalties shall accrue, but need not be paid, during the pendency of any dispute resolution procedures undertaken pursuant to this Consent Order. The determination of whether stipulated penalties are due and owing will be made in connection with the resolution of the dispute.

4. Nothing contained herein shall be construed to grant jurisdiction to any court to review EPA's decision made hereunder.

XX. FORCE MAJEURE

1. Respondents shall perform all the requirements of this Consent Order according to the time limits set out in the Consent Order, and referenced supporting documents or any modification thereto, unless their performance is prevented or delayed by events which constitute Force Majeure. In the event there is an inconsistency between this Consent Order and any of the other referenced supporting documents as to time limits, including the Work Plan, the time limits set forth in this Consent Order shall control.

2. "Force Majeure" for purposes of this Consent Order is defined as any event arising from causes beyond the control of Respondents or their authorized representatives (including but not limited to their officers, directors, agents, employees, contractors, subcontractors, successors, and assigns) which delays or prevents the timely performance of any obligation under this Consent Order, and could not have been overcome or prevented by Respondents' due diligence to overcome the delay. Respondents shall have the burden of proving that the delay was caused by circumstances beyond the control of Respondents and that Respondents exercised due care and due diligence to anticipate any potential Force Majeure event and to address the effects of any potential Force Majeure event (1) as it is occurring and (2) following the potential Force Majeure event, such that the delay is minimized to the greatest extent possible. Respondents reserve the right to demonstrate that under appropriate circumstances, events beyond the control of Respondents include but are not limited to: adverse weather conditions; injunctions and other orders issued by courts or administrative agencies; unanticipated break-down or accident to machinery or equipment despite diligent maintenance. EPA reserves the right to contend that any of the above circumstances do not constitute a Force Majeure event.

3. Force Majeure shall not include increased costs or expenses of any Work performed under this Consent Order, nor the financial inability of Respondents to perform such Work, nor the failure of Respondents to make timely application for any required permits or approvals, and to provide all information required therefor in a timely manner.

4. Respondents shall have the burden of proving by a preponderance of the evidence that any delay is or will be a Force Majeure event and that the duration of the delay requested is necessary to compensate for that event.

5. In the event of a Force Majeure, the time for performance of the activity delayed by the Force Majeure shall be extended for the minimum time necessary to allow completion of the delayed activity but in no event for a period longer than the period of the delay attributable to the Force Majeure. The time for performance of any activity dependent on the delayed activity shall be similarly extended. EPA shall determine whether and to what extent the time for performance shall be extended. Respondents shall adopt all practicable measures to avoid or minimize any delay caused by a Force Majeure.

6. In the event Respondents discover an event which Respondents believe is a Force Majeure, Respondents shall orally notify EPA's Project Coordinator no later than two (2) working days after Respondents become aware of the occurrence of such event.

Respondents shall notify EPA, in writing, no later than twelve (12) days after oral notification is due under this subparagraph. Written notification shall include an explanation of why the event meets the requirements of Force Majeure under this Section, which of the tasks are directly affected by the delay, the measures taken and to be taken to prevent or minimize the delay, and a statement as to whether in Respondents' opinion, such event may cause or contribute to an endangerment to public health, welfare, or the environment.

7. EPA shall determine whether the event constitutes Force Majeure and so notify Respondents in writing. If EPA agrees that a delay is or was attributable to the Force Majeure event, EPA and Respondents shall modify the requirements of the Work to provide such additional time as may be necessary to allow the completion of the specific phase of Work and/or any succeeding phase of the Work affected by such delay, with such additional time not to exceed the actual duration of the delay. An extension of the time for performance of the obligation directly affected by the Force Majeure event shall not, of itself, extend the time for performance of any subsequent obligation but in appropriate cases may require such an extension. In the event that EPA and Respondents cannot agree that any delay in the Work has been or will be caused by a Force Majeure event, or as to the appropriate length of the delay, the dispute shall be resolved by

the Director, Hazardous Waste Management Division, Region 9, who will undertake to resolve the dispute consistent with the NCP and the terms of this Consent Order. In any such proceeding, Respondents shall have the burden of demonstrating by a preponderance of the evidence that the delay or anticipated delay has been or will be caused by a Force Majeure event, that the duration of the delay was or will be warranted under the circumstances, and that Respondents complied with the requirements of this Section. Respondents shall then implement EPA's decision. During the pendency of the dispute, Respondents shall not be relieved from their duty to timely complete all other tasks required by this Consent Order in accordance with the schedule set forth herein. If EPA determines that the event did not constitute Force Majeure then any delay caused by the event claimed to be Force Majeure by Respondents shall constitute noncompliance with the Consent Order and penalties shall accrue from the date of noncompliance. Nothing contained herein shall be construed to grant jurisdiction to any court to review EPA's decision made hereunder.

8. In determining whether Respondents have exercised due diligence to overcome or prevent a Force Majeure event, EPA shall consider Respondents' compliance with the requirements of this Section.

9. Failure to comply with the requirements of this Section shall preclude Respondents from asserting any claim of Force Majeure.

XXI. STIPULATED PENALTIES

1. Respondents shall be liable to EPA, as provided for in this Section, for stipulated penalties in the amounts set forth below for failure to comply with the requirements of this Consent Order, unless excused under Section XX (Force Majeure) or Section XIX (Dispute Resolution). Failure to comply with this Consent Order includes failure to comply with any requirement of this Consent Order either in a timely manner or in an adequate manner.

2. For each day that Respondents fail to meet the requirements set forth in this Consent Order, Respondents each agree to pay the sum(s) set forth below in accordance with the following schedule, as stipulated penalties:

a. For any failure of Respondents to timely or adequately meet each of the elements of the compliance schedule set forth in Subsection 3 of Section VII (Work to be Performed), including the timely and adequate performance of the requirements of the Inspection Plan, Respondents shall pay a stipulated penalty according to the following schedule:

<u>Period of Noncompliance</u>	<u>Penalty Per Day Per Violation</u>
--------------------------------	--------------------------------------

Days 1-10	\$ 750
Days 11-20	\$1500
Days 21-45	\$3000
Days 46 and beyond	\$6000

b. For any failure of Respondents to timely or adequately meet any of the deadlines or requirements imposed by this Consent Order (other than those specifically set forth in Subsection 3 of Section VII (Work to be Performed), which are covered by Subsection a. of this Section), Respondents shall pay a stipulated penalty according to the following schedule:

<u>Period of Noncompliance</u>	<u>Penalty Per Day Per Violation</u>
--------------------------------	--------------------------------------

Days 1-10	\$ 500
Days 11-20	\$1000
Days 21-45	\$2000
Days 46 and beyond	\$4000

3. EPA shall give Respondents written notification of Respondents' failure to comply with any requirement of this Consent Order in an adequate manner and identify the nature of the noncompliance. The notice also shall indicate the amount of penalties then due, and the rate of accrual for continuous violations. Failure of EPA to provide Respondents with notice under this Subsection shall not stay the accrual of stipulated penalties.

4. All penalties shall begin to accrue on the first (1st) day after (a) the deadline on which complete performance is due, or (b) a violation occurs or (c) for laboratory analysis, the date of Respondents' receipt of sample results which demonstrate noncompliance, and continue to accrue until the requirement is satisfied, unless performance is excused pursuant to this Consent Order. Nothing herein shall prevent the simultaneous accrual of separate penalties for separate violations of this Consent Order.

5. Any stipulated penalty incurred by Respondents shall be paid upon demand by certified or cashier's check payable to "EPA Hazardous Substances Superfund" and addressed to:

U.S. Environmental Protection Agency
Region 9, Superfund Accounting
P.O. Box 360863M
Pittsburgh, PA 15251
Attention: Collection Officer for Superfund

The face of the check shall indicate that the payment is being made in connection with the "Phoenix-Goodyear Airport Superfund Site-Removal Action." All stipulated penalties under this Section shall be paid within sixty (60) days of Respondents' receipt of the written demand for payment of stipulated penalties. Failure to pay a stipulated penalty on time also constitutes an event subject to stipulated penalties under Subsection 2.b. of this Section. The check shall be accompanied by a

letter identifying this Consent Order and describing the basis for the penalties. A copy of the letter and the check shall be sent simultaneously to the EPA Project Coordinator.

6. Payment of stipulated penalties shall not preclude EPA from electing to pursue any other remedy or sanction to enforce this Consent Order, and nothing shall preclude EPA from seeking statutory penalties against Respondents for violations of this Consent Order or of the statutes and regulations upon which it is based.

7. Any noncompliance with EPA-approved reports, plans, specifications, schedules, appendices, and attachments that are required under this Consent Order shall be considered a failure to comply with this Consent Order and subject to stipulated penalties as governed by this Section.

8. No payments made under this Section shall be tax deductible for federal or State income tax purposes.

9. Notwithstanding any other provision of this Section, EPA may, in its sole discretion, reduce or waive stipulated penalties for a violation of this Consent Order.

XXII. CLAIMS AGAINST THE FUND

Nothing in this Consent Order shall be deemed to constitute a preauthorization of a CERCLA claim within the meaning of Sections 111 or 112 of CERCLA, 42 U.S.C. Sections 9611 or 9612, or 40 C.F.R. Section 300.25(d). In consideration of the issuance of

this Consent Order, Respondents agree not to make any claims pursuant to Section 111, Section 112 or Section 106(b)(2) of CERCLA, 42 U.S.C. Sections 9611, 9612, 9606(b), or any other provisions of law directly or indirectly against the Hazardous Substance Superfund, or make other claims against EPA for those costs expended in connection with this Consent Order.

XXIII. OTHER CLAIMS

With respect to any person, firm, partnership or corporation not a signatory to this Consent Order, nothing in this Consent Order shall constitute or be construed as a covenant not to sue by any signatory with respect to, or a release from any claims, cause of action, or demand in law or equity.

XXIV. OTHER APPLICABLE LAWS

All actions required to be taken pursuant to this Consent Order shall be undertaken in accordance with the requirements of all applicable federal, state and local laws and regulations.

XXV. EFFECTIVE DATE AND SUBSEQUENT MODIFICATION

1. The effective date of this Consent Order shall be the date on which it is signed by EPA.

2. This Consent Order may be amended by mutual agreement of EPA and Respondents. Such amendments shall be in writing and shall have as their effective date the date on which such amendments are signed by EPA.

XXVI. REIMBURSEMENT OF PAST RESPONSE COSTS

Respondents shall pay seventy-two thousand two hundred twenty-one dollars (\$72,221.00) to EPA for response costs incurred by the United States prior to and including January 31, 1990 relating to the Site that were attributable to the Chrome Sludge Drying Beds ("Past Response Costs"). Respondents shall pay such Past Response Costs in accordance with Paragraph XXII (Reimbursement of U.S. Past Response Costs) of the Consent Decree for the final remedy at the Site. Future response and oversight costs pertaining to the Chrome Sludge Drying Beds, i.e., those incurred after January 31, 1990, will be reimbursed in accordance with Section XXVII (Reimbursement of Future Response and Oversight Costs) of this Consent Order.

XXVII. REIMBURSEMENT OF FUTURE RESPONSE AND OVERSIGHT COSTS

1. Respondents shall reimburse the Hazardous Substance Superfund for all response costs incurred by EPA and its contractors after January 31, 1990 relating to the clean-up of the Chrome Sludge Drying Beds required by this Consent Order ("Future Response and Oversight Costs"). Response costs means those costs incurred by EPA and its contractors pursuant to CERCLA not inconsistent with the NCP, and shall include but are not limited to, all oversight, administrative, enforcement, removal, investigative and remedial or other direct or indirect costs related to or in connection with this Consent Order. Respondents reserve their

right to demonstrate that such costs are inconsistent with the NCP. EPA's costs shall be documented by EPA's Agency Financial Management System Summary data ("SPUR reports") and EPA's Cost Documentation Management System report ("CDMS report"). No more than annually, EPA shall submit to Respondents documentation of response and oversight costs incurred by EPA in the time period since the last demand for payment. EPA's SPUR reports and the CDMS reports shall serve as the documentation for payment demands. EPA will also provide a summary of its indirect cost calculations. Respondents shall, within sixty (60) days of receipt of each demand for payment, remit a check for the amount of those costs made payable to the Hazardous Substances Superfund and addressed as indicated in Section XXI (Stipulated Penalties). Interest shall not accrue within such sixty (60) day time period if Respondents pay the full amount of each demand for payment.

2. EPA may, at its election, bill Respondents for Future Response and Oversight Costs for the clean-up of the Chrome Sludge Drying Beds as part of its annual billing of future response and oversight costs under Section XXI of the Consent Decree for the final remedy at the Site. If EPA elects to do so, EPA (or the United States, as the case may be) shall state in its submission to Respondents that the costs for which it seeks reimbursement include Future Response and Oversight Costs for the clean-up of the Chrome Sludge Drying Beds, and EPA (or the United

States, as the case may be) agrees to highlight to the extent practicable in such combined billing those Future Response and Oversight Costs which pertain to the clean-up of the Chrome Sludge Drying Beds.

XXVIII. TERMINATION AND SATISFACTION

Upon completion of the Work performed pursuant to this Consent Order, Respondents shall submit to EPA a written certification that they have fully satisfied their obligations in accordance and in full compliance with this Consent Order. The provisions of this Consent Order, including Respondents' obligations under Section VII (Work to be Performed), shall be deemed satisfied upon Respondents' receipt of such written approval from EPA, provided that termination of this Consent Order shall not alter the provisions of Section XIII (Site Access), Section XXII (Claims Against the Fund), Section XV (Record Preservation), Section XVII (Indemnification), Section XVI (Reservation of Rights), Section XXI (Stipulated Penalties) and such other continuing rights and obligations of Respondents under this Consent Order, including the post-closure activities to be performed by Respondents pursuant to the Inspection Plan.

XXIX. PENALTIES FOR NONCOMPLIANCE

Respondents may be subject to civil penalties under Section 106(b) of CERCLA, 42 U.S.C. Section 9606(b), of not more than \$25,000 for each day in which Respondents or either one of them

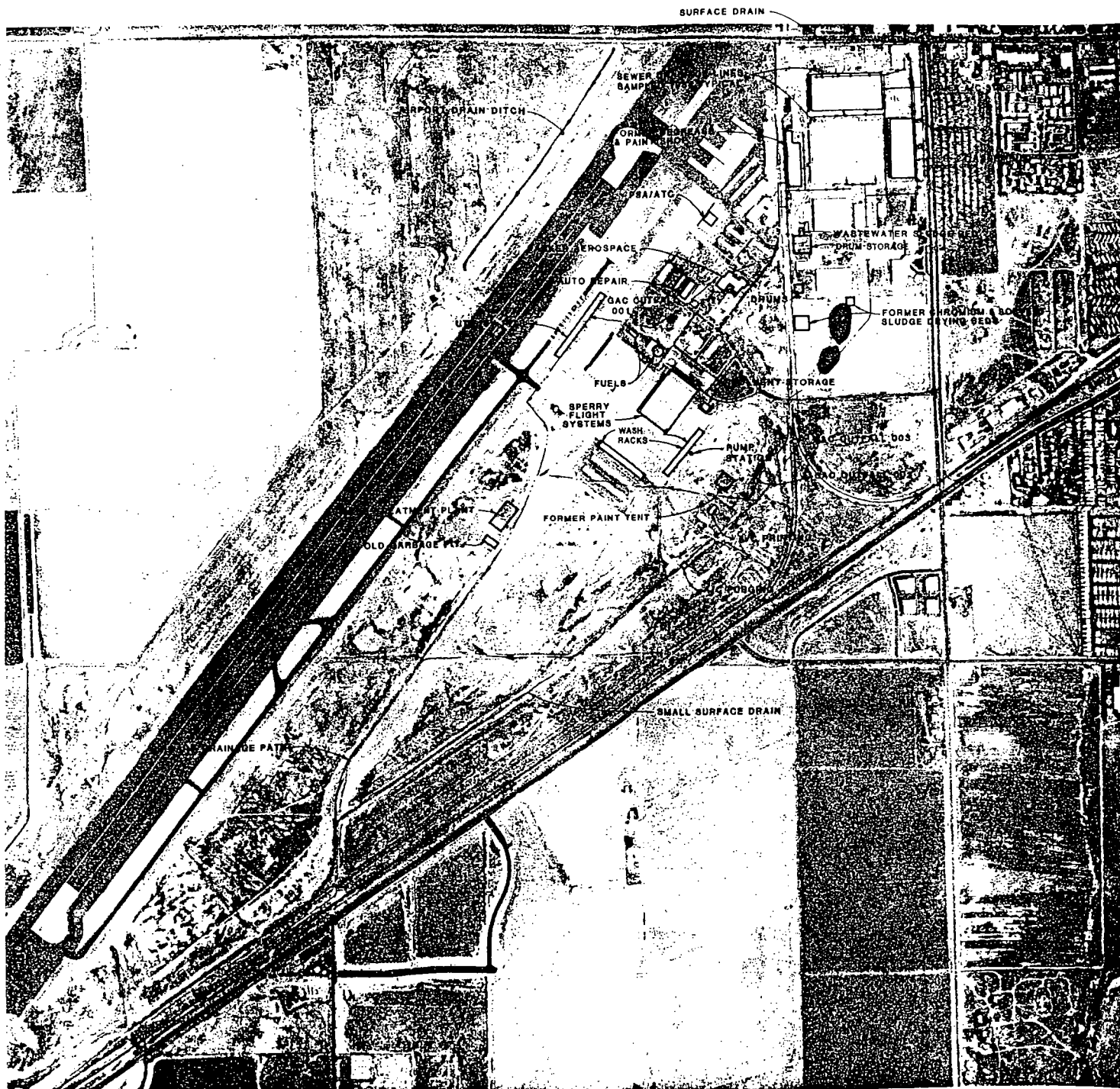


FIGURE 1.

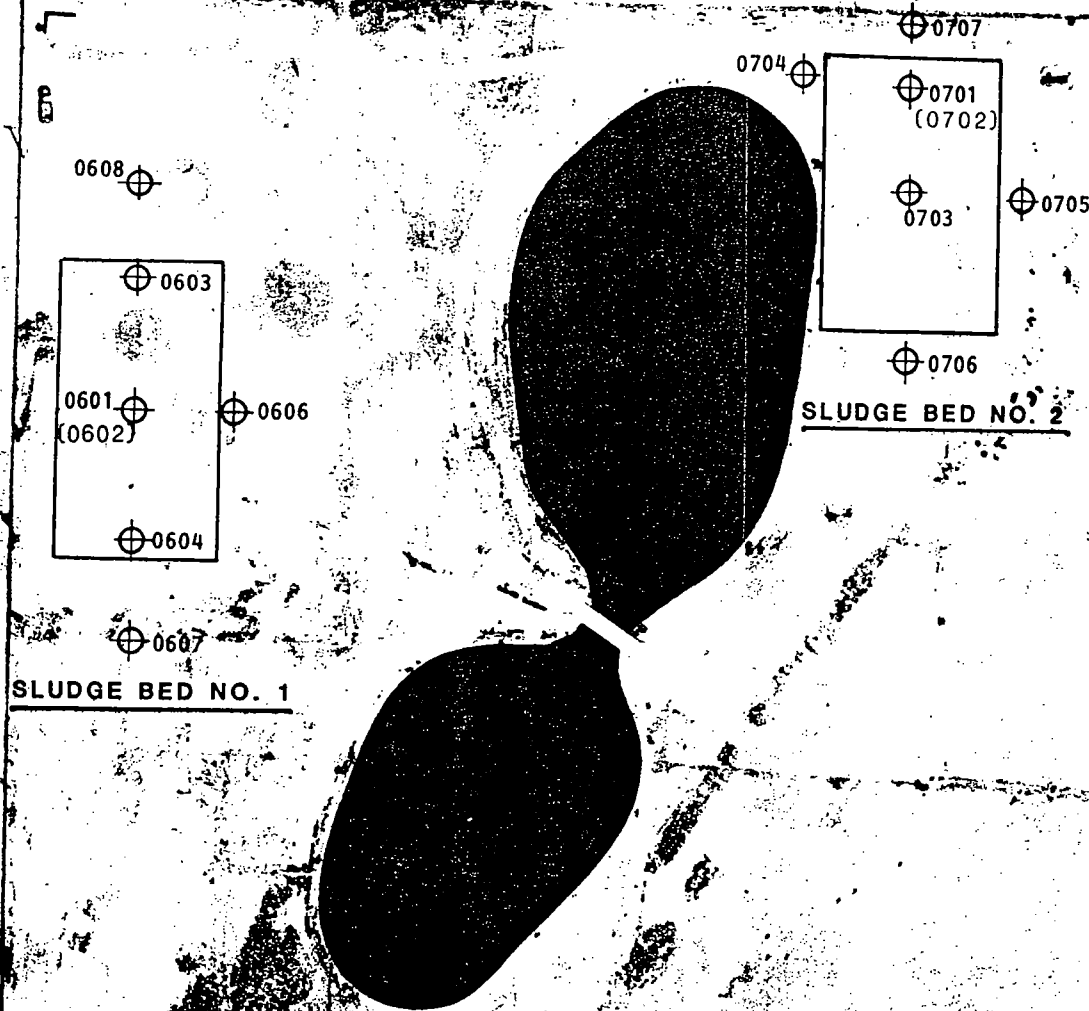


FIGURE 2.

SAMPLE LOCATIONS EMPLOYED TO INVESTIGATE THE AREA OF SLUDGE DRYING BED NO. 2 (SB-2)

PHOENIX-GOODYEAR AIRPORT SUPERFUND SITE (SOUTH) CHROMIUM RESPONSE ACTION WORK PLAN

Prepared for:

Goodyear Tire & Rubber Company
1144 East Market Street
Akron, Ohio 44316

Prepared by:

ICF Technology Incorporated

October 11, 1991

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ACRONYMS

EP	Extraction Procedure
EPA	U.S. Environmental Protection Agency
FS	Feasibility Study
FSP	Field Sampling Plan
GAC	Goodyear Aerospace Corporation
HASP	Health and Safety Plan
HBGL	Draft Health-Based Guidance Level
PGA	Phoenix-Goodyear Airport
QAP	Quality Assurance Plan
RI	Remedial Investigation
SB-2	Sludge Drying Bed No. 2
TCLP	Toxicity Characteristic Leaching Procedure
XRF	X-Ray Fluorescence

PHOENIX-GOODYEAR AIRPORT SUPERFUND SITE (SOUTH) CHROMIUM RESPONSE ACTION WORK PLAN

INTRODUCTION

Purpose

This plan was prepared to describe the proposed approach to the non-time critical removal action of metal contaminated soils at the Phoenix-Goodyear Airport (PGA) site (south). A feasibility study has been completed for the chrome sludge-drying beds area of the former Goodyear Aerospace Corporation (GAC) property and resulted in a conclusion that a removal action is required to reduce the potential for risk arising from contact with chromium-bearing soils.

Background

GAC was created out of the Goodyear Aircraft operation to provide products for the aerospace industry. Products included electronic equipment, transparent products such as windshields, structural equipment such as the MX missile transporter, and aluminum shelters. GAC also provided manufacturing and installation services under contract to the Department of Defense. One of the activities associated with GAC operations was chrome-plating. As a result of the plating work, acids and chromate sludge were discharged as wastes.

Prior to 1980, chromate sludges were treated to reduce Cr(VI) to Cr(III) and disposed in three drying beds as depicted in Figures 1 and 2. The larger bed was located in the southwestern portion of the fenced property and was used from the early 1970's until 1980. The two smaller beds were located south of the plant on the northern edge of the current pond and were in use until about 1976. Waste sludges were later removed from the beds and redispersed in compliance with prevailing regulations. However, subsequent sampling and analysis during the remedial investigation (RI) has revealed that chromium and cadmium residues remain in the vicinity of the two smaller drying beds.

In 1989, a feasibility study (FS) was conducted for the chrome sludge drying beds to determine what, if any, remedy should be applied. Analysis of the available data revealed that total chromium levels are as high as 30,000 mg/Kg soil in sludge drying bed no. 2 (SB-2) but that most samples do not exceed criteria as hazardous wastes when subjected to the Extraction Procedure (EP) test. (The EP was the required testing procedure at the time the RI was conducted. Since that time, the Toxicity Characteristic Leaching Procedure [TCLP] has been promulgated. Subsequent characterization will be accomplished with the TCLP.) Similarly, total cadmium levels as high as 112 mg/Kg have been observed, but cadmium solubilized by the EP fell below criteria for defining hazardous wastes. Hence, the primary risk posed by metal residues was thought to arise from direct ingestion or suspension of dusts as opposed to soluble transport in ground water. The feasibility study concluded that if further action was required, capping would be the most cost-effective approach.

Subsequent to review of the FS, the State of Arizona has indicated that the Draft Health-Based Guidance Levels (HBGL) for state soils are 2,000 mg/Kg total chromium and 100 mg/Kg

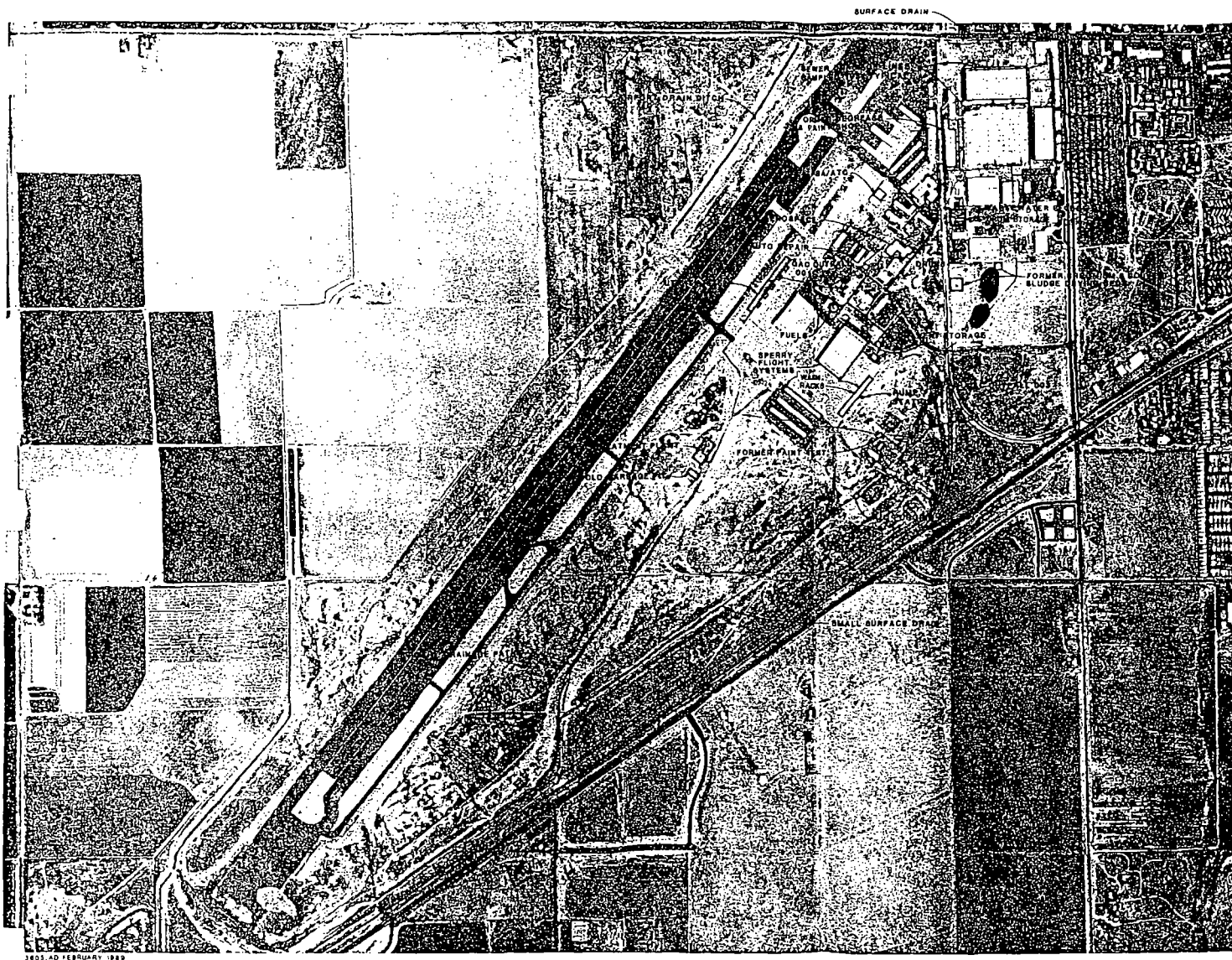
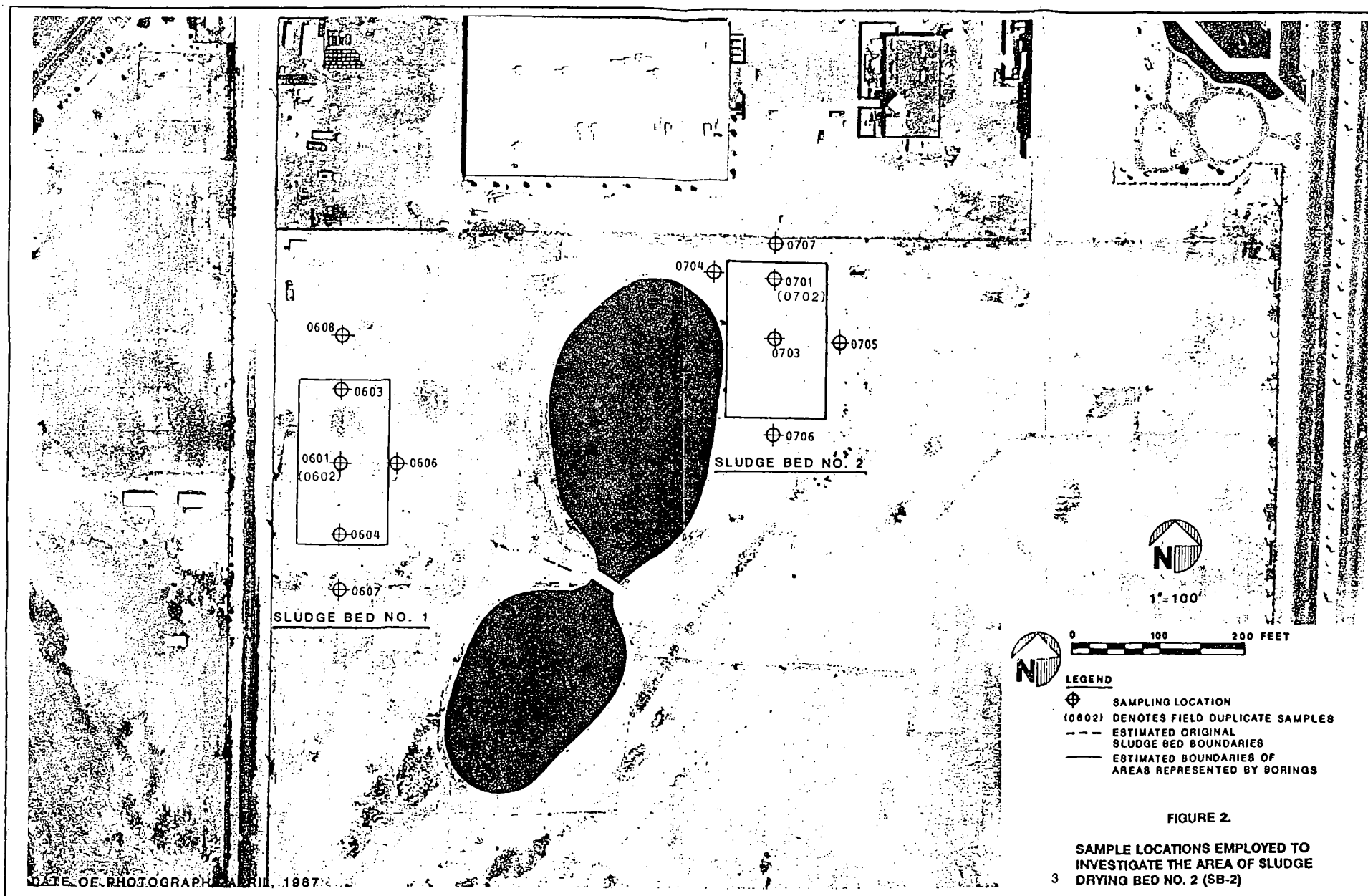


FIGURE 1.

2 THE PHOENIX-GOODYEAR AIRPORT
SITE (SOUTH) AND LOCATION OF
THE CHROME SLUDGE DRYING BEDS



cadmium. As a consequence, some level of action will be required at the chrome sludge drying beds. This plan describes the non-time critical removal action objectives and discusses the proposed approach and implementation plan to meet those objectives.

CURRENT CONDITIONS

As noted in the preceding section, soil sampling and analysis have revealed that sludge relocation activities carried out by Goodyear Tire and Rubber Company did not eliminate all soils with elevated chromium and cadmium. The FS and the Technical Memorandum entitled "Soil Sampling at the GAC Sludge Drying Beds" (ICF, 1988) document the nature and extent of the remaining metal contamination in and around the sludge drying beds. Figures 3 through 10 depict the current estimate of the location of isopleths for total chromium and cadmium at sludge bed no. 2 (SB-2). SB-2 was the only area found to contain chromium concentrations in excess of the Arizona prescribed HBGL of 2,000 mg/Kg. A single soil sample was found to contain cadmium at levels above the Arizona HBGL of 100 mg/Kg. That sample was observed to contain 112 mg/Kg cadmium while a duplicate contained 63 mg/Kg. As is apparent from comparison of the Figures 2 through 5, the chromium concentration at depth is off-set from that on the surface. The highest concentrations are encountered at a depth of three feet, and not at the surface.

REMOVAL ACTION OBJECTIVE

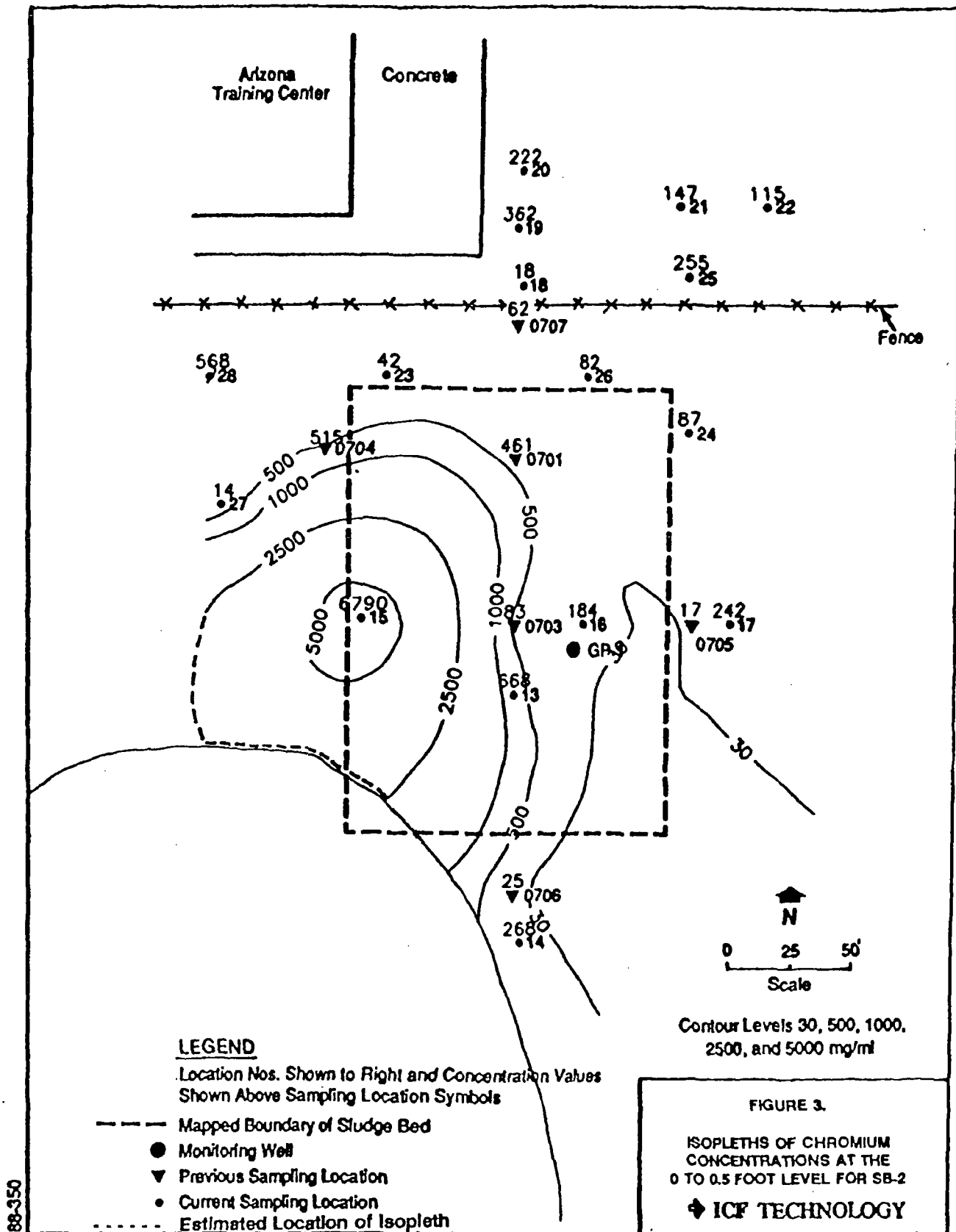
Based on the results of the RI/FS activities and subsequent comments from the Arizona Department of Environmental Quality, the removal action objective has been developed to stabilize all soils containing more than 2,000 mg/Kg total chromium and/or 100 mg/Kg cadmium (Arizona HBGL for those two metals) in such a manner as to:

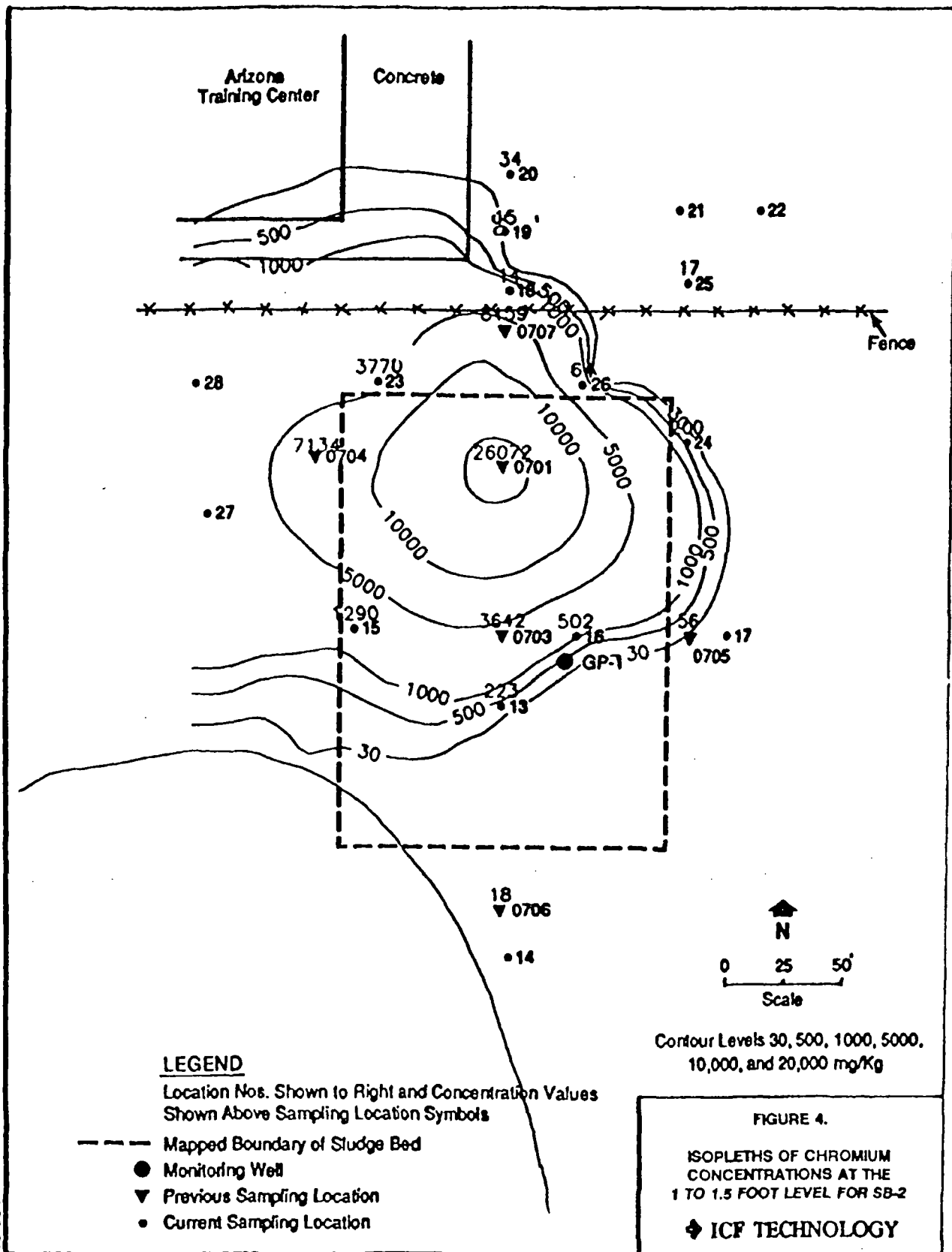
- 1) Prevent suspension of dusts containing chromium or cadmium in excess of Arizona HBGL;
- 2) Prevent formation of leachate in excess of TCLP limits; and
- 3) Ensure that particle sizes will withstand normal weathering and abrasion forces.

The objective is focused on eliminating the direct ingestion and inhalation pathways by ensuring that loose surface soils are not contaminated to the extent that they pose a risk through direct ingestion or inhalation of dust resuspended by wind or on-site activities. The leaching criteria relates to the ground water pathway even though only a minor threat to ground water has been identified to date. (As noted previously, on September 25, 1990, the TCLP replaced the EP as the appropriate test to determine if a solid waste is to be regulated as hazardous on the basis of the potential to generate toxic leachate.) Particle size resistance to weathering and abrasion is included to preserve the protection provided by the stabilization over extended periods of time.

APPROACH

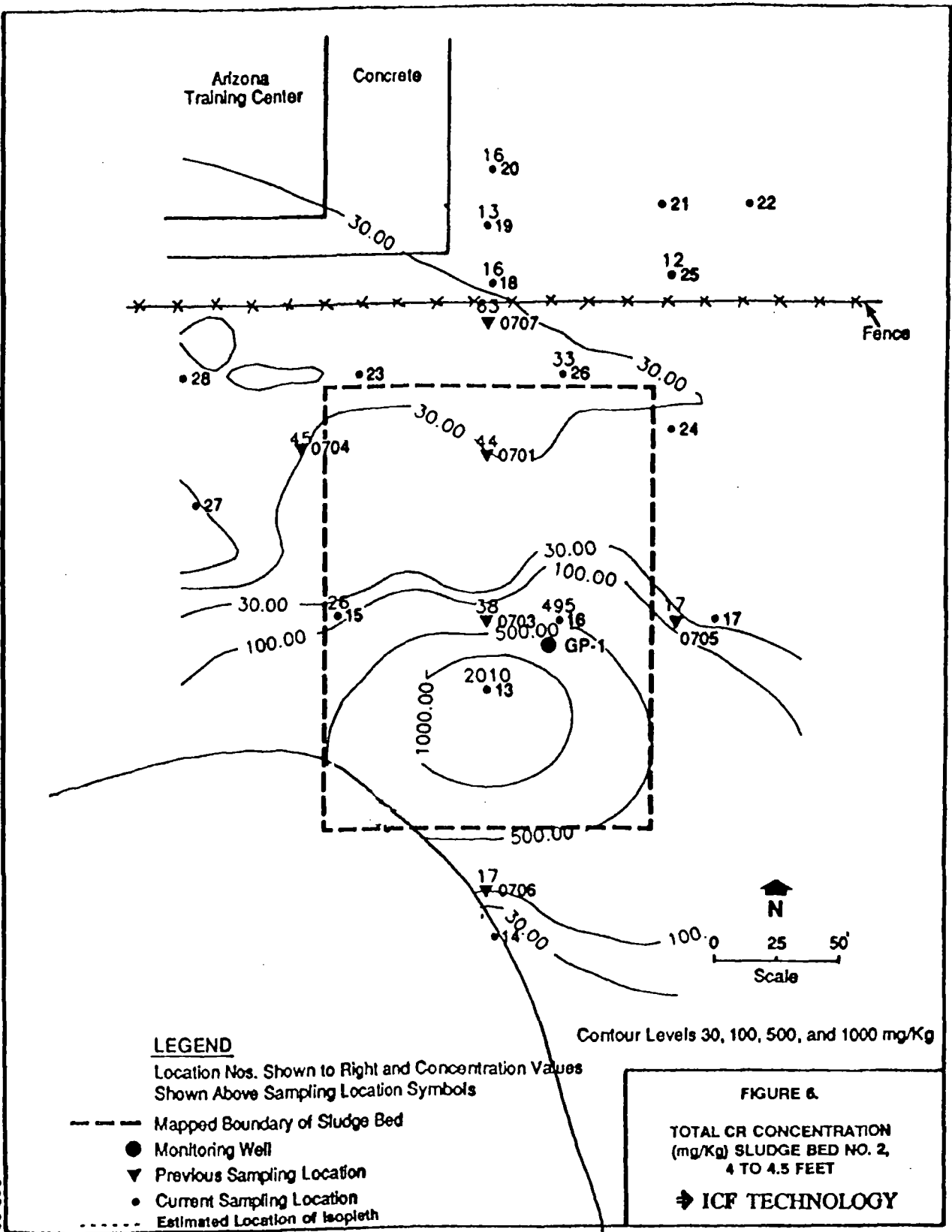
The approach selected for the removal action at the chrome sludge drying beds is stabilization of soils with chromium concentrations in excess of 2,000 mg/Kg or cadmium concentrations in

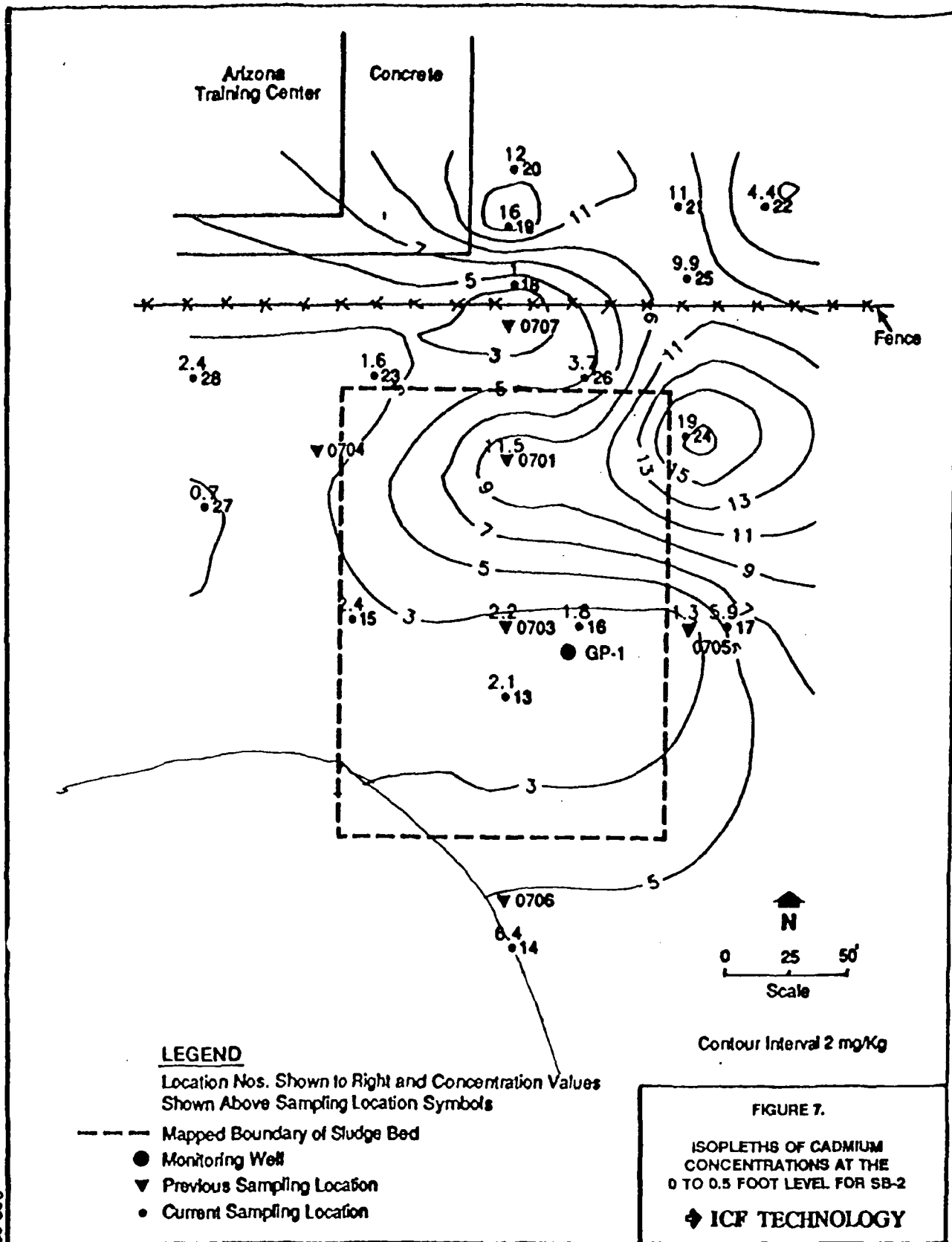






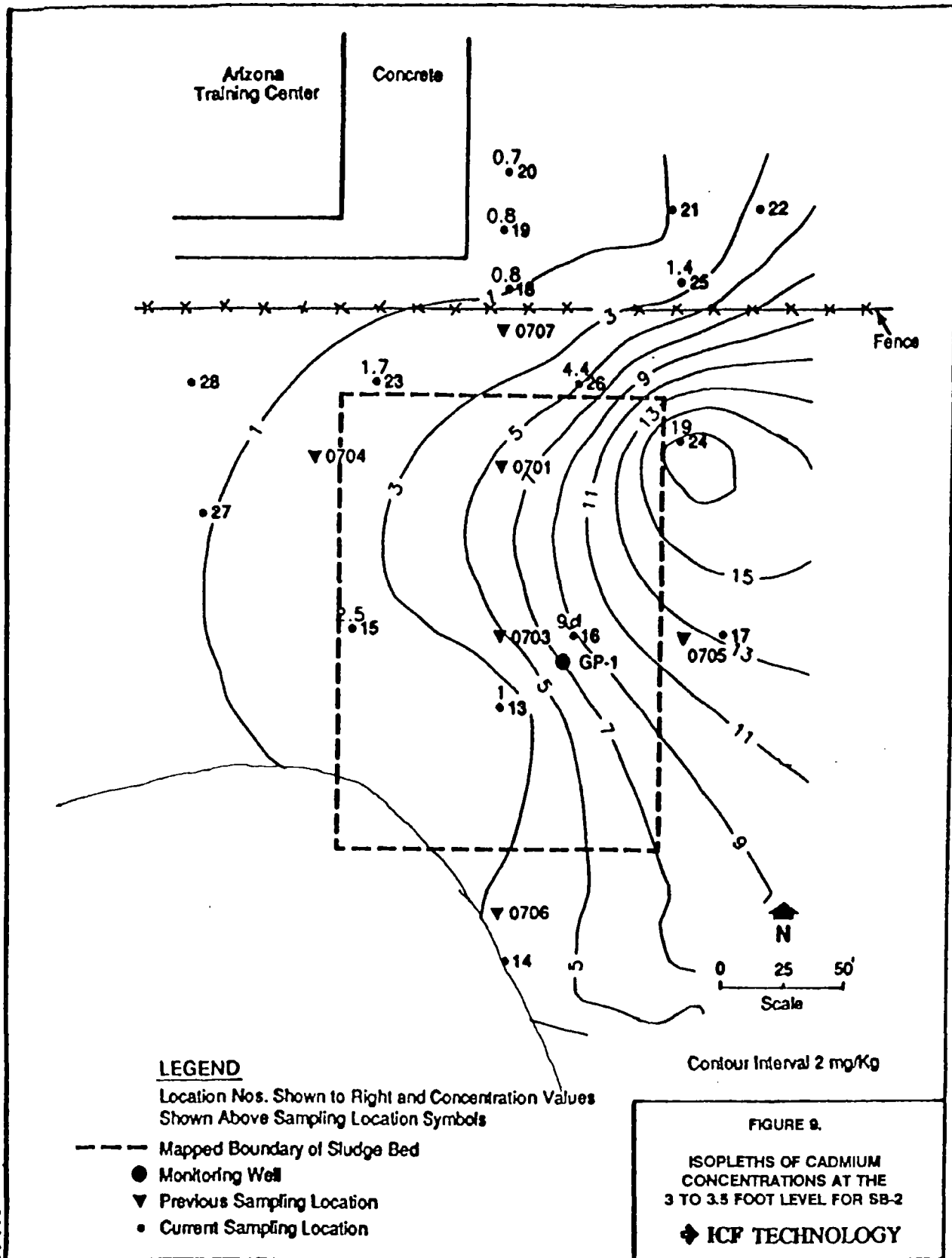
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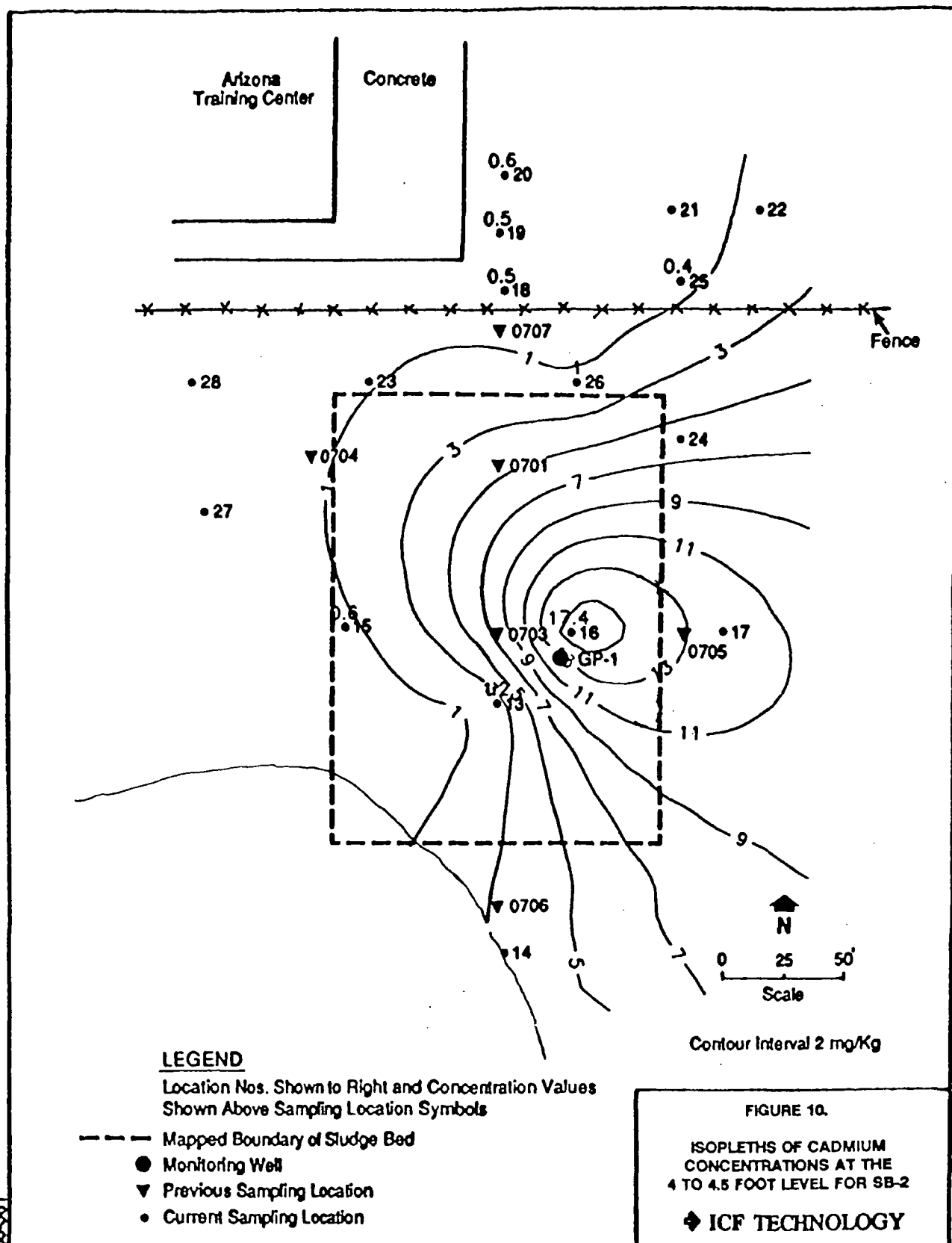


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88-360



excess of 100 mg/Kg. All soils which exceed Arizona HBGL will be excavated and stabilized. The stabilized mass will then be placed back in the excavation and covered with clean fill soils.

The overall approach meets the removal action objective for the chrome sludge drying beds. The direct ingestion pathway is eliminated by stabilizing the surface soils into larger sized particles and putting a cover of clean fill over them.

The dust suspension pathway will also be eliminated by stabilizing contaminated particles into clasts too large to be suspended by the wind. Specifications for the stabilized product will include a minimum strength characteristic to prevent the production of suspendable dusts as a result of normal abrasive forces. In addition, the clean soil cover over the cap will separate the stabilized soil from the wind and traffic which could otherwise create the opportunity for suspension of dust.

Migration to ground water will be significantly reduced. This will be accomplished by ensuring that the stabilized product complies with the treatment standards contained in the RCRA Land Disposal Restrictions (LDR) regulations. Specifically, using the TCLP procedure, the stabilized product will meet the most stringent of the F006, D006, and D007 treatment standards for cadmium and chromium, i.e., 0.066 ppm and 5.0 ppm, respectively. The values are the lower of the two standards, 5.0 ppm Cr for D007 wastes compared to 5.2 ppm for F006 and 0.066 ppm Cd for F006 compared to 1 ppm for D006. While the legal requirement is to meet the F006 LDR treatment standards, Goodyear has chosen to meet the lower 5.0 limit for chromium used for TCLP designation to further protect against future migration of metals.

This approach assures meeting the applicable RCRA LDR requirements since F006, D006, and D007 are the only waste categories relevant to the residues found on site.

IMPLEMENTATION

Implementation of the removal action will proceed in a series of seven steps as outlined below:

- 1) Develop specific design criteria and product specifications;
- 2) Select the stabilization contractor;
- 3) Map out surface contours of the soil to be stabilized;
- 4) Expose the underground fire main and storm sewers, and then encase them in cement;
- 5) Excavate areas to be stabilized and segregate cover soils;
- 6) Stabilize soils and reposition the product in the stabilized area; and
- 7) Cover and grade with clean fill soil, monitor.

Each of these steps is described in more detail in the following sections.

Bid Design Specifications

The initial task in the proposed removal action will be the development of the final contractor specifications for the stabilized soil. The stabilized soil must be capable of meeting the removal action objective. As a consequence, bid requests will include specifications for the particle size, leachability, and resistance to particle size attrition of the product. A compressive strength specification is not included since it is not relevant to a granular product. Concern for product integrity relates to the maintenance of particle size which is addressed with the attrition criteria. Vendors will be required to bid on the basis of forming a stabilized soil product with particle size greater than or equal to 50 μm diameter, leachate below TCLP limits, and greater than 90 percent passing a modified ASTM C131-89 abrasion test.

The particle size diameter of 50 μm was selected to represent the threshold at which stabilized product particles would be likely to migrate upward into the atmosphere during wind storms or on-site activities. Soil and soil-like particles on the ground surface move through three discrete mechanisms:

- 1) Surface creep - the rolling and creeping of large particles (greater than 1,000 μm diameter) due to collisions by smaller more mobile particles;
- 2) Saltation - lifting and horizontal convection of particles large enough to extend above the laminar layer at the atmosphere-ground interface (50 to 1,000 μm diameter) so that wind forces overcome gravity resulting in lift; and
- 3) Suspension - ejection of particles from the laminar layer by collisions from saltation particles followed by subsequent convection and slow descent due to the small particle size (diameters less than 50 μm).

Saltation and surface creep rarely result in particles moving more than a foot above the ground regardless of wind speed. As a consequence, it is the suspension phenomenon that is of primary interest for contaminant-related public health concerns since suspension mobilized particles are the only ones that will reach the levels where people are likely to inhale them (Bander, 1982¹).

Use of a threshold value of 50 μm diameter provides a level of safety since particles greater than 15 μm in size are rarely inhaled. In general, particles less than 3.5 μm in diameter are most often considered respirable (Sehmel, 1980²).

The original ASTM C131-89 abrasion test is described in Appendix A. The test has been modified to include no metal spheres. The metal spheres are used in ASTM C131-89 to provide significant size attrition and thereby broaden the range of results to give good relative results across products. As noted by ASTM, the test with the spheres present can not be used as a

¹Bander, T. J. 1982. "Literature Review of Models for Estimating Soil Erosion and Deposition from Wind Stresses on Uranium Mill Tailings Covers." NUREG/CR-2768, PNL-4302. Prepared for Nuclear Regulatory Commission. Battelle, Pacific Northwest Laboratories, Richland, Washington.

²Sehmel, G. A. 1980. "Particle Resuspension: A Review." Environment International, Vol. 4, pp. 107-127. Pergamon Press.

measure of absolute performance because it does not relate to any natural phenomena. By removing the spheres, the test simulates the movement of particles against each other as would happen if mobilized by natural (wind and runoff) or anthropogenic (vehicles, walking) forces. The product will be deemed acceptable if after the prescribed tumbling time, greater than 90 percent of the particles still exceed the minimum 50 μm diameter, i.e., after abrasion, the product is still too large to be suspended by the wind.

The TCLP treatment standards are included to ensure that the stabilized soil does not generate leachate with sufficient chromium or cadmium concentrations to threaten ground water quality. The thickness of the cover soil will be specified at greater than or equal to 1 foot. The final volume of soil to be stabilized and the ratio of stabilization agent to soil will determine the volume of the stabilized product and therefore the elevation of the regraded excavation after backfill. A large volume of soil and a high reagent mix could result in a thicker stabilized layer.

The U.S. Environmental Protection Agency (EPA) will review and comment on the bid request package. A formal approval of the package is not required. It is Goodyear's intent to find a contractor that will bid the entire removal action as a package with the exception of the sampling and analysis work. An independent contractor will perform the analyses to determine the amount of soil requiring excavation and the level of residues remaining after excavation. Hence, Goodyear will act as a prime contractor with two subcontractors: 1) the sampling and analysis contractor; and 2) the removal action contractor.

The bid request will indicate a range of potential soil volumes in order to assure that the contractor can accommodate unanticipated increases in the volume of soil to be excavated. The range will encompass twice the volume currently estimated from available data.

Contractor Selection

The second step in the implementation will be to select the stabilization contractor. Preliminary bid requests were issued during the work plan preparation activities to vendors offering stabilization agents/services. Several of the vendors collected samples of contaminated soils from SB-2 to test product quality and determine the probable reagent-to-soil ratio requirements. Estimates were received back from the following six firms:

WATEC

In-Situ Fixation

OHM

VFL

Earth Resources Company - ERC

GKM Hayward-Baker

When the final bid specifications are completed, a request for quotes will be sent to each of these vendors as well as any new local vendors identified in the interim.

Bids in response to the request for quotes will first be screened to identify those which can meet or exceed all product specifications. The costs will then be compared among the qualified bidders and that bid offering the greatest value to Goodyear considering both cost and product quality will be selected.

The successful removal action contractor will be required to prepare a complete work plan for the effort including a Health and Safety Plan (HASP). The HASP will address provisions for dust suppression and on-site air monitoring during the removal action. The sampling and analysis contractor will be required to prepare a Field Sampling Plan (FSP) and a Quality Assurance Plan (QAP). The FSP will include provisions for both on-site analyses and confirmational analyses at an off-site laboratory. Goodyear will see that the plans from the two contractors are integrated into the overall work plan. The EPA will be provided a copy of the work plan including the HASP, FSP and QAP, for review, comment and approval. No site work will be conducted prior to the final approval of all of the plan elements.

Site Mapping

The third step in the implementation process will be to map the surface of SB-2, stake out the location of the three underground utilities, and identify the area of soil that must be stabilized. The existing data for the top 0.0 to 0.5 feet of soil (Figure 2) provide a partial picture of the extent of chromium contamination. However, the western perimeter of the contamination north of the pond has not been defined, and the 2,000 mg/Kg isopleth has been estimated only. An onsite, real time effort is planned to provide these missing data. Similar missing data at depth will be acquired with analysis of soils on the side walls and bottom of the excavation as it proceeds.

A surface survey will be conducted with a portable X-ray fluorescence (XRF) instrument to delineate the 2,000 mg/Kg chromium contour (as well as any areas where cadmium exceeds 100 mg/Kg). The XRF provides rapid turn around analysis for metals that is accurate to 50 to 400 mg/Kg for chromium and 50 mg/Kg for cadmium depending on the matrix. Reference articles on XRF use and its accuracy are provided in Appendix B. Samples will be collected from a grid pattern and analyzed for total chromium and cadmium content. Results will be plotted on a site map and marked on stakes driven into SB-2 to provide a clear outline of the area where chromium concentrations are greater than or equal to 2,000 mg/Kg and/or cadmium concentrations exceed 100 mg/Kg. The staked area will be used to segregate those soils which must be stabilized when excavated. Soils with chromium and cadmium concentrations below HBGL that are excavated to allow for grading and preparation of the sub-base will be stockpiled for use as intermediate cover over the stabilized product, but underneath imported clean soils.

Utility Encasement

Three underground utilities traverse the area where excavation and stabilization activities will be conducted (see Figure 11 in map pocket): 1) a 48 inch storm drain oriented in a northeast-southwest direction in the northern half of the work area; 2) a 12 inch storm drain running north south and intersecting the 48 inch line from the north near the northeast corner of the work area; and 3) a 10 inch fire fighting water supply line running east-west on the northern edge of the work area. In order to protect these utilities from damage during the removal action as well as to provide added protection against infiltration in the future, the lines will be exposed and encased in a six inch cocoon of concrete prior to initiation of excavation. Encasement will be accomplished by the removal action contractor guided by identification stakes installed during the mapping/survey task.

Excavation

The fifth step of the removal action will be excavation of all soils requiring stabilization. The HBGL isopleths at depth do not lie directly beneath the surface isopleths of the same value. Therefore, the excavation will extend beyond the surface isopleths to cover any portion of SB-2 and areas adjacent to SB-2 that has had chromium concentrations greater than or equal to 2,000 mg/Kg (or cadmium greater than or equal to 100 mg/Kg) as delineated in Figure 12. Initial excavation will encompass a rectangle 213 feet by 225 feet. Depths will vary (estimated at 0.5 to 5.0 feet) depending on the concentration of chromium and/or cadmium encountered. As noted in the preceding section, the contaminated soils will be segregated for stabilization while the other soils will be stockpiled for use as intermediate cover. Soils for intermediate cover will be tested to confirm that they are not toxicity characteristic hazardous wastes. The contractor will also be required to present a plan for dust control as a part of the site health and safety plan.

As the excavation proceeds, the XRF will be used to map out all soils with chromium or cadmium in excess of HBGL. These soils will be excavated and put with other contaminated soils for stabilization. Excavation will continue until no soils remain with chromium or cadmium concentrations in excess of the HBGL. At the time that XRF results indicate no soils exceed the HBGL, samples will be taken and sent to an off-site laboratory for confirmation. It is estimated that there will be 4,000 cubic yards of contaminated soil and 733 cubic yards of other soil. The final volume will be determined by the XRF results and, ultimately, by confirmation at an off-site laboratory. A set of maps will be prepared to show the extent of excavation and final contours for the isopleths in excess of HBGL.

All soils will be stockpiled on polyethylene sheets and covered with polyethylene sheets between and after excavation activities. No soils will be stored for a period of more than 90 days.

Stabilization

The sixth step in the removal action will be stabilization and emplacement of the stabilized soil back in the excavation. The contaminated soils will be mixed with the selected reagent and placed on a polyethylene sheet to cure. Based on an estimated reagent-to-soil ratio of 1.0 to 1.0 and an estimated volume of 4,000 cubic yards of contaminated soil, the stabilized product will rise approximately 1.7 feet above the original grade. The one foot of clean cover will bring the total increase to 2.7 feet. Samples of cured product will be taken and analyzed prior to reburial to assure that all product specifications are met. If the stabilized material does not meet the required specification, an appropriate modification will be designed on the basis of the failure mode.

Closure and Post-Closure Monitoring

A cover of clean soil will be placed over the stabilized material. The cover will consist of 1.0 feet of total soil including the stockpiled intermediate cover and imported clean soil with background levels of chromium and cadmium. Placement of the intermediate cover shall also comply with 40 CFR 268 (the land disposal restrictions). Closure will require 47,925 cubic feet of soil, of which 19,800 cubic feet will have been stockpiled from the earlier excavation. Therefore, an additional 28,125 cubic feet of clean soil will be imported to complete the cover with a 7.0 inch layer. The cover soil will cause the excavated area to be raised a maximum of 2.7 feet. The actual cover will be graded to a 3 foot center height and a no greater than 3% slope out to the sides to minimize erosion potential. The soil will be compacted and covered with a minimum of

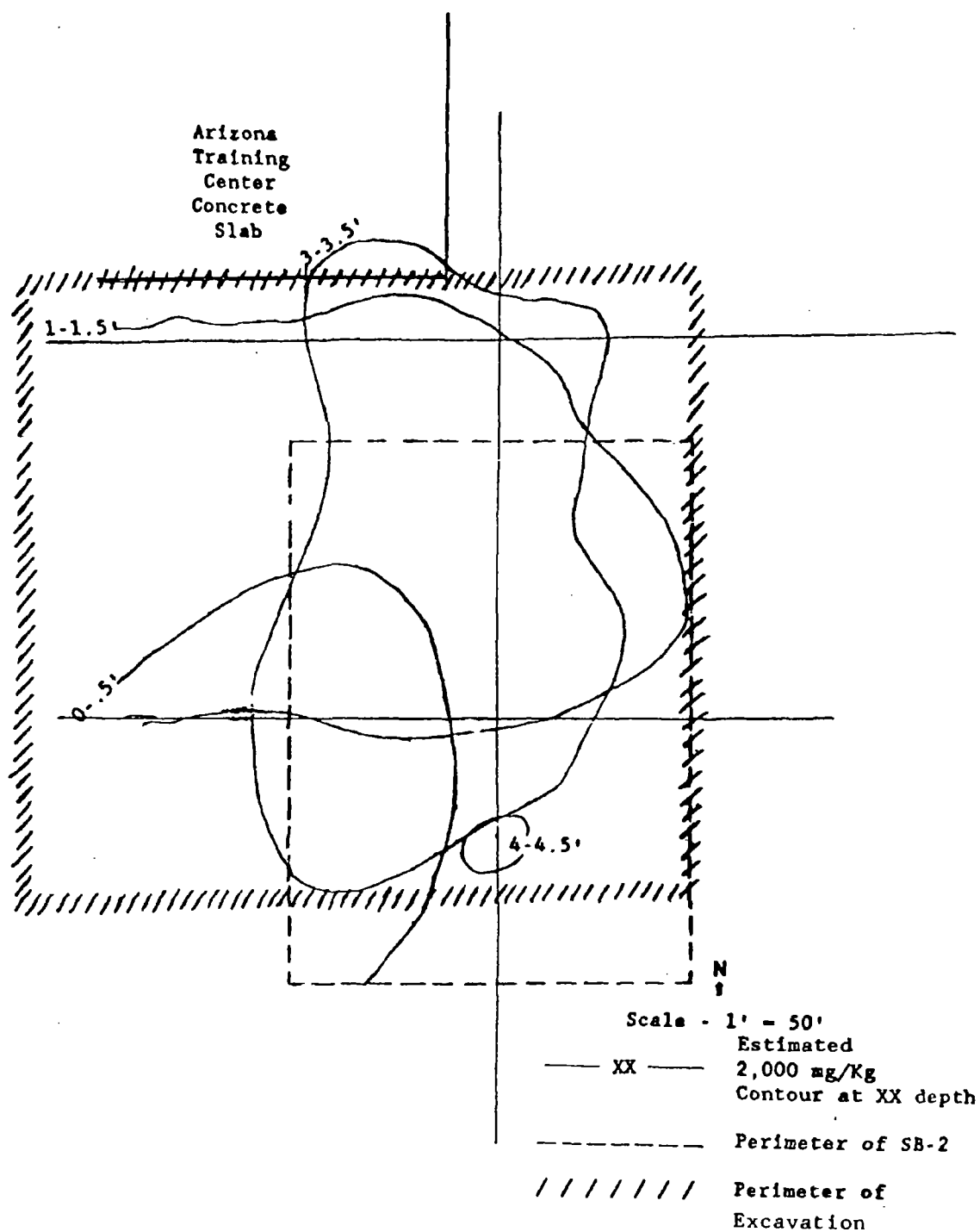


FIGURE 12. EXTENT OF EXCAVATION ACTIVITIES

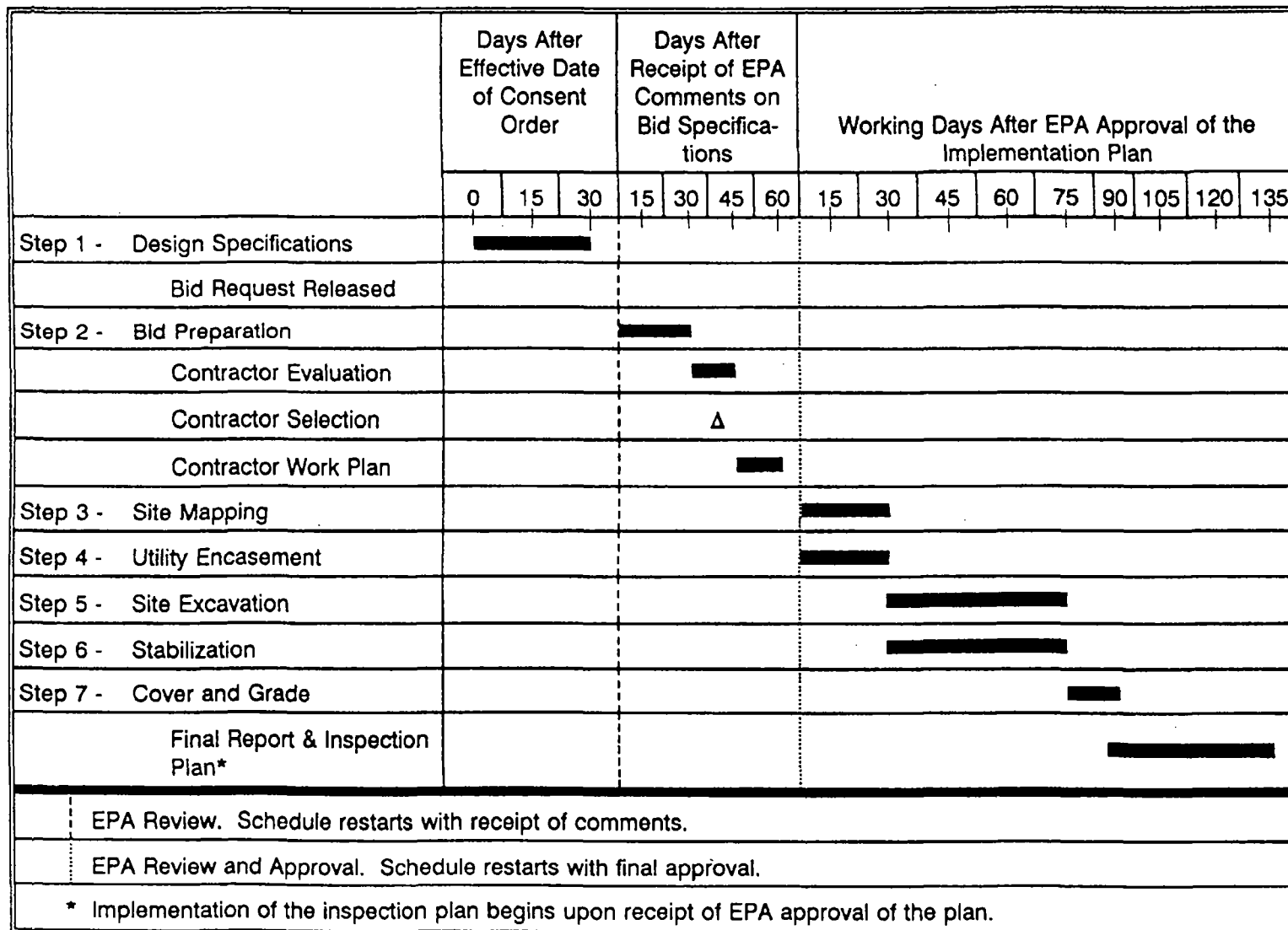
three inches of gravel with a diameter of greater than 0.75 inches. Gravel placement will conform to the grading specifications and will taper at the edges to minimize erosion potential. In addition, an east-west, 6-foot wide walking path of compacted mag mortar sand will be placed in the gravel as illustrated in Figure 11. Maintenance of the cover, inspection of the cover for signs of erosion, and corrective action as appropriate will be defined as obligations for all current and future owners.

A separate program has not been devised to monitor ground water conditions after closure since an active monitoring program is underway with respect to the Operable Unit Remedy for Subunit A. In conjunction with the Subunit A monitoring, Wells EMW-4, EMW-3, EMW-6 and 16GP-1 will be sampled and analyzed for chromium on a semiannual basis until the aquifer is declared clean and further monitoring is waived.

SCHEDULE

The proposed removal action will be completed over a period of 6 months. Timing of individual activities is illustrated in Figure 13. EPA review will occur at three points: 1) review and comment on the bid request package 30 working days into the process; 2) review, comment and approval of the contractor's work plan 90 working days into the process; and 3) approval of the final closure 180 working days after initiation of the removal action.

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APPENDIX A

PROCEDURE FOR ASTM C131-89

**(Procedure is to be modified by removing
item 5.4 from the apparatus - the steel spheres.)**



Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine¹

This standard is issued under the fixed designation C 131; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

1. Scope

1.1 This test method covers a procedure for testing sizes of coarse aggregate smaller than $1\frac{1}{2}$ in. (37.5 mm) for resistance to degradation using the Los Angeles testing machine.

NOTE 1—A procedure for testing coarse aggregate larger than $\frac{3}{4}$ in. (19 mm) is covered in Test Method C 535.

2. Referenced Documents

2.1 ASTM Standards:

C 136 Method for Sieve Analysis of Fine and Coarse Aggregates²

C 535 Test Method for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine²

C 670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials²

C 702 Practice for Reducing Field Samples of Aggregate to Testing Size²

D 75 Practice for Sampling Aggregates²

E 11 Specification for Wire-Cloth Sieves for Testing Purposes³

3. Summary of Test Method

3.1 The Los Angeles test is a measure of degradation of mineral aggregates of standard gradings resulting from a combination of actions including abrasion or attrition, impact, and grinding in a rotating steel drum containing a specified number of steel spheres, the number depending upon the grading of the test sample. As the drum rotates, a shelf plate picks up the sample and the steel spheres, carrying them around until they are dropped to the opposite side of the drum, creating an impact-crushing effect. The contents then roll within the drum with an abrading and grinding action until the shelf plate impacts and the cycle is repeated. After the prescribed number of revolutions, the contents are removed from the drum and the aggregate portion is sieved to measure the degradation as percent loss.

4. Significance and Use

4.1 The Los Angeles test has been widely used as an indicator of the relative quality or competence of various sources of aggregate having similar mineral compositions. The results do not automatically permit valid comparisons to be made between sources distinctly different in origin, composition, or structure. Specification limits based on this test should be assigned with extreme care in consideration of available aggregate types and their performance history in specific end uses.

5. Apparatus

5.1 *Los Angeles Machine*—The Los Angeles testing machine, conforming in all its essential characteristics to the design shown in Fig. 1, shall be used. The machine shall consist of a hollow steel cylinder, closed at both ends, having an inside diameter of 28 ± 0.2 in. (711 ± 5 mm), and an inside length of 20 ± 0.2 in. (508 ± 5 mm). The cylinder shall be mounted on stub shafts attached to the ends of the cylinder but not entering it, and shall be mounted in such a manner that it may be rotated with the axis in a horizontal position within a tolerance in slope of 1 in 100. An opening in the cylinder shall be provided for the introduction of the test sample. A suitable, dust-tight cover shall be provided for the opening with means for bolting the cover in place. The cover shall be so designed as to maintain the cylindrical contour of the interior surface unless the shelf is so located that the charge will not fall on the cover, or come in contact with it during the test. A removable steel shelf extending the full length of the cylinder and projecting inward 3.5 ± 0.1 in. (89 ± 2 mm) shall be mounted on the interior cylindrical surface of the cylinder, in such a way that a plane centerex between the large faces coincides with an axial plane. The shelf shall be of such thickness and so mounted, by bolts or other suitable means, as to be firm and rigid. The position of the shelf shall be such that the distance from the shelf to the opening, measured along the outside circumference of the cylinder in the direction of rotation, shall be not less than 5 in. (1.27 m).

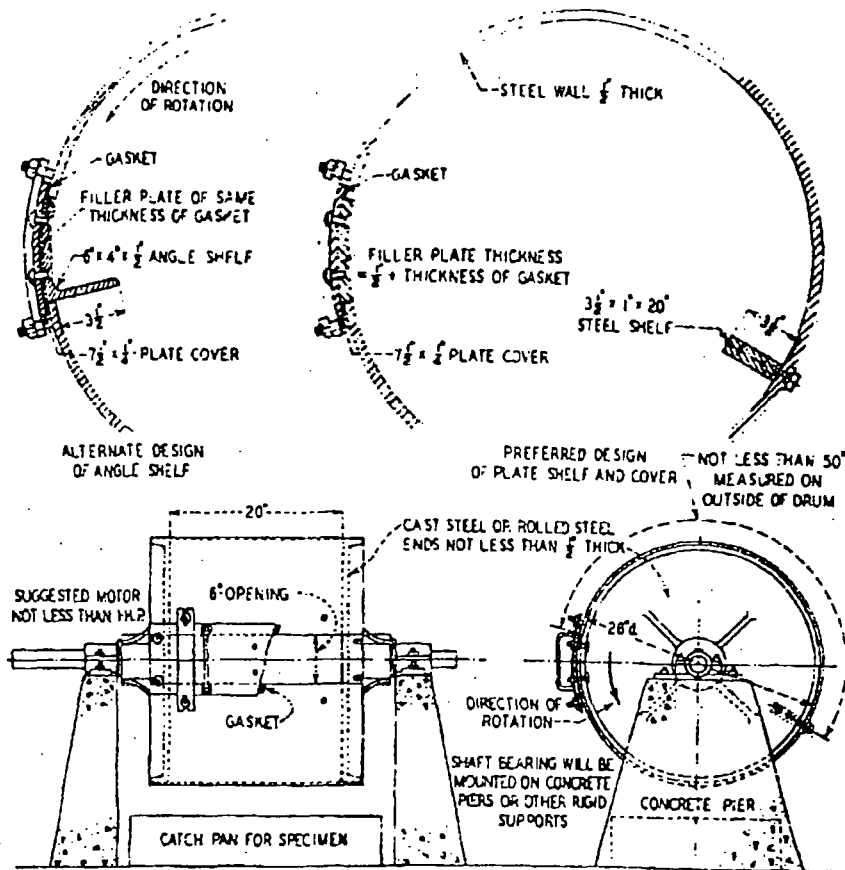
NOTE 2—The use of a shelf of wear-resistant steel, rectangular in cross section and mounted independently of the cover, is preferred. However, a shelf consisting of a section of rolled angle, properly mounted on the inside of the cover plate, may be used provided the direction of rotation is such that the charge will be caught on the outside face of the angle. If the shelf becomes distorted from its original shape to such an extent that the requirements given in X1.2 of the Appendix to this method are not met, the shelf shall either be repaired or replaced before additional tests are made.

¹ This test method is under the jurisdiction of ASTM Committee C-9 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.03.05 on Methods of Testing and Specifications for Physical Characteristics of Concrete Aggregates.

Current edition approved June 15, 1989. Published June 1989. Originally published as C 131 - 37 T. Last previous edition C 131 - 81(1987).

² Annual Book of ASTM Standards, Vols 04.02 and 04.03.

³ Annual Book of ASTM Standards, Vol 14.02.



Metric Equivalents

in.	1/4	1/2	1	3/4	4	6	7 1/2	20	28	50
mm	6.4	12.7	25.4	89	102	152	190	508	711	1270

FIG. 1 Los Angeles Testing Machine

5.1.1 The machine shall be so driven and so counterbalanced as to maintain a substantially uniform peripheral speed (Note 3). If an angle is used as the shelf, the direction of rotation shall be such that the charge is caught on the outside surface of the angle.

NOTE 3—Back-lash or slip in the driving mechanism is very likely to finish test results which are not duplicated by other Los Angeles machines producing constant peripheral speed.

5.2 Sieves, conforming to Specification E 11.

5.3 Balance—A balance or scale accurate within 0.1 % of load over the range required for this test.

5.4 Charge—The charge shall consist of steel spheres grading approximately 1 7/32 in. (46.8 mm) in diameter and each weighing between 390 and 445 g.

5.4.1 The charge, depending upon the grading of the test sample as described in Section 7, shall be as follows:

Grading	Number of Spheres	Weight of Charge, g
A	12	5000 ± 25
B	11	4584 ± 25
C	8	3330 ± 20
D	6	2500 ± 15

NOTE 4—Steel ball bearings 1 1/4 in. (46.0 mm) and 1 1/2 in. (47.6 mm) in diameter, weighing approximately 400 and 440 g each.

respectively, are readily available. Steel spheres 1 7/32 in. (46.8 mm) in diameter weighing approximately 420 g may also be obtainable. The charge may consist of a mixture of these sizes conforming to the weight tolerances of 5.4 and 5.4.1.

6. Sampling

6.1 The field sample shall be obtained in accordance with Practice D 75 and reduced to test portion size in accordance with Methods C 702.

7. Test Sample

7.1 The test sample shall be washed and oven-dried at 221 to 230°F (105 to 110°C) to substantially constant weight (Note 5), separated into individual size fractions, and recombined to the grading of Table 1 most nearly corresponding to the range of sizes in the aggregate as furnished for the work. The weight of the sample prior to test shall be recorded to the nearest 1 g.

8. Procedure

8.1 Place the test sample and the charge in the Los Angeles testing machine and rotate the machine at a speed of 30 to 33 rpm for 500 revolutions. After the prescribed number of revolutions, discharge the material from the

TABLE 1 Gradings of Test Samples

Sieve Size (Square Openings)		Weight of Indicated Sizes, g			
Passing	Retained on	Grading			
		A	B	C	D
37.5 mm (1½ in.)	25.0 mm (1 in.)	1 250 ± 25	...	...	...
25.0 mm (1 in.)	19.0 mm (¾ in.)	1 250 ± 25	...	...	...
18.0 mm (¾ in.)	12.5 mm (½ in.)	1 250 ± 10	2 500 ± 10	...	...
12.5 mm (½ in.)	9.5 mm (⅜ in.)	1 250 ± 10	2 500 ± 10	...	...
9.5 mm (⅜ in.)	6.3 mm (¼ in.)	...	...	2 500 ± 10	...
6.3 mm (¼ in.)	4.75-mm (No. 4)	...	...	2 500 ± 10	...
4.75-mm (No. 4)	2.36-mm (No. 8)	...	...	...	5 000 ± 10
Total		5 000 ± 10	5 000 ± 10	5 000 ± 10	5 000 ± 10

machine and make a preliminary separation of the sample on a sieve coarser than the 1.70-mm (No. 12). Sieve the finer portion on a 1.70-mm sieve in a manner conforming to Method C 136. Wash the material coarser than the 1.70-mm sieve (Note 5), oven-dry at 221 to 230°F (105 to 110°C) to substantially constant weight, and weigh to the nearest 1 g (Note 6).

NOTE 5—If the aggregate is essentially free of adherent coatings and dust, the requirement for washing before and after test may be waived. Elimination of washing after test will seldom reduce the measured loss by more than about 0.2 % of the original sample weight.

NOTE 6—Valuable information concerning the uniformity of the sample under test may be obtained by determining the loss after 100 revolutions. This loss should be determined without washing the material coarser than the 1.70-mm sieve. The ratio of the loss after 100 revolutions to the loss after 500 revolutions should not greatly exceed 0.20 for material of uniform hardness. When this determination is made, take care to avoid losing any part of the sample; return the entire sample, including the dust of fracture, to the testing machine for the final 400 revolutions required to complete the test.

9. Calculation

9.1 Express the loss (difference between the original weight and the final weight of the test sample) as a

percentage of the original weight of the test sample. Report this value as the percent loss.

NOTE 7—The percent loss determined by this method has no known consistent relationship to the percent loss for the same material when tested by Test Method C 535.

10. Precision

10.1 For nominal 19.0-mm (¾-in.) maximum size coarse aggregate with percent losses in the range of 10 to 45 %, the multilaboratory coefficient of variation has been found to be 4.5 %.⁴ Therefore, results of two properly conducted tests from two different laboratories on samples of the same coarse aggregates should not differ from each other by more than 12.7 %⁴ of their average. The single-operator coefficient of variation has been found to be 2.0 %.⁴ Therefore, results of two properly conducted tests by the same operator on the same coarse aggregate should not differ from each other by more than 5.7 % of their average.⁴

10.2 Bias—Since there is no accepted reference material suitable for determining the bias for this procedure, no statement on bias is being made.

⁴ These numbers represent, respectively, the (15%) and (D25%) limits as described in Practice C 670.

APPENDIX

(Nonmandatory Information)

XI. MAINTENANCE OF SHELF

X1.1 The shelf of the Los Angeles machine is subject to severe surface wear and impact. With use, the working surface of the shelf is peened by the balls and tends to develop a ridge of metal parallel to and about 1 1/4 in. (32 mm) from the junction of the shelf and the inner surface of the cylinder. If the shelf is made from a section of rolled angle, not only may this ridge develop but the shelf itself may be bent longitudinally or transversely from its proper position.

mine that it is not bent either lengthwise or from its normal radial position with respect to the cylinder. If either condition is found, the shelf should be repaired or replaced before further tests are made. The influence on the test result of the ridge developed by peening of the working face of the shelf is not known. However, for uniform test conditions, it is recommended that the ridge be ground off if its height exceeds 0.1 in. (2 mm).

X1.2 The shelf should be inspected periodically to deter-

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This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, PA 19103.

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APPENDIX B

**PUBLICATIONS DESCRIBING THE USE AND UTILITY
OF X-RAY FLUORESCENCE FOR FIELD
CHARACTERIZATION OF METALS IN SOILS**



**SIXTH ANNUAL
WASTE TESTING
AND
QUALITY ASSURANCE
SYMPOSIUM**

**JULY 16-20, 1990
GRAND HYATT WASHINGTON
WASHINGTON, D.C.**

PROCEEDINGS
Volume I

USE OF FIELD MOBILE X-RAY FLUORESCENCE SPECTROMETRY FOR ON-SITE SCREENING OF HEAVY METAL CONTAMINATION ON SUPERFUND SITES.

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Abstract

The on-site analyses of priority pollutants contained in the soil is essential to expedite the solution to this nation's hazardous waste problems efficiently and cost effectively. This paper will describe a sampling and on-site analytical technique, utilizing EDXRF technology, to determine the concentration levels at several sampling depths of the most prevalent inorganic soil contaminants (Copper, Lead and Zinc) at Franklin Burn Site I in Gloucester County, New Jersey. One hundred and thirty (130) samples were collected and analysed by this method. The EDXRF generated results were used to produce toxic-graphical maps for each target contaminant at several depths to visually depict the contamination and off-site migration.

Introduction

Heavy metal contamination is an important environmental problem at many Superfund sites. The usual method for obtaining analytical results is to collect samples, ship them to a laboratory and have them analyzed by the Environmental Protection Agency (EPA) approved Contract Laboratory Program (CLP). This results in a delay of several weeks between shipment of samples and receipt of the analytical results with an additional delay for review by the Quality Assurance (QA) and Quality Control (QC) staff of EPA. Such delays habitually require remobilisation of crews to the site for additional sampling in order to delineate the extent and depth of contamination for effective assessment and remediation of Superfund sites.

In order to streamline mapping and clean-up operations, the EPA has instituted the Field Analytical Screening Program (FASP) to facilitate on-site screening(2). The availability of a field mobile, analytical quality Energy Dispersive X-Ray Fluorescence (EDXRF) spectrometer makes it possible for a crew to collect, analyse and map data for samples while on location. Statistical analysis can be applied to determine where additional samples should be selected and analysed in order to define the extent of contamination. This program minimises the number of samples sent to CLP and eliminates the need to remobilise crews(1).

Site Background

Franklin Burn Site I is located on a remote 4 acre lot in a rural area of Franklin Township, as shown in Figure 1. The site was used for over twenty years as a copper reclamation operation. Copper wire, capacitors, transformers and other electrical equipment were burned in an open fire to remove the insulation. The charred insulation fell directly on the ground, releasing toxic substances into the soil and atmosphere. PCB laced transformer fluids were also burned, producing dioxin. The burn operation generated approximately 110,000 cubic feet of hard packed ash. A preliminary assessment, performed by the Technical Assistance Team of the U.S. EPA Removal Action Branch, showed that hazardous materials were present at the site in concentrations that endanger public health and the environment. The analytical results obtained during the assessment indicated the presence of chlorinated dioxins/furans, PCBs and heavy metals. This unique mix of

pollutants presents significant health and disposal issues. Public access to the site is of primary concern due to the lack of site security and numerous shallow potable wells located in the general vicinity.

Problem Encountered

The first task was to delineate the horizontal extent and depth of contamination for determination of site boundaries and total waste volume. To achieve this goal, a large number of soil samples needed to be collected on a regular grid pattern at various depths. These samples must then be analysed for heavy metal content. The most widely used approach has been to send all of the samples to a CLP laboratory for analysis. This technique has several inadequacies:

1. **Very Expensive**
The cost of CLP analysis for heavy metal content is approximately \$200 per sample. When a large number of sample points are required this procedure becomes cost prohibitive. The cost of analysing 130 samples for TCL Metals by CLP is roughly \$26,000.
2. **Long Waiting Period**
CLP results are usually obtained four weeks from the time samples are submitted for Routine Analytical Service (RAS).
3. **Remobilisation**
After the results are reviewed and mapped additional areas of concern are usually identified which require remobilisation of crews to obtain further samples. This increases both the cost and waiting period.

The NJDEP guidelines for some selected metals are presented in Table 2.

Table 2
NJDEP Soil Action Levels

Cu - 170 PPM	Zn - 350 PPM
Pb - 350 PPM	Ni - 100 PPM
As - 20 PPM	Cd - 3 PPM

The method detection limits using these excitation conditions for the metals analysed are given in Table 3.

Table 3
EDXRF Method Detection Limits

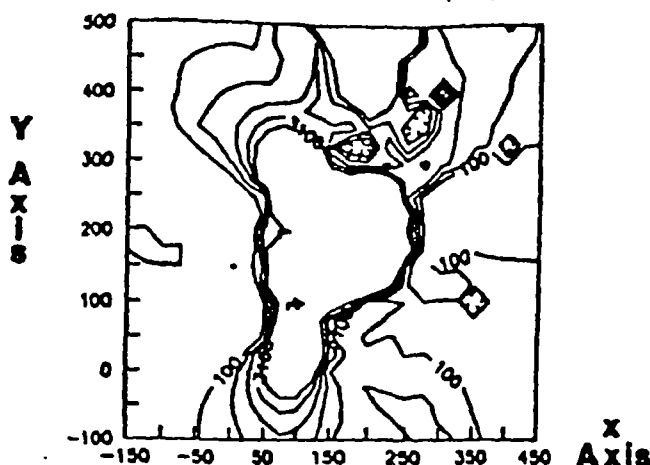
Cu - 15 PPM	Zn - 12 PPM
Pb - 19 PPM	Ni - 25 PPM
As - 20 PPM	Cd - 19 PPM

As can be readily seen, the EDXRF method detection limits are below NJDEP standards. Quantitative analyses of X-ray spectra were performed using a Fundamental Parameters computer program. The program automatically corrects for any matrix enhancement or absorption effects based on stored physical constants. This eliminates the need for any site specific samples previously analysed by the CLP to calibrate the instrument.[1] By removing the need for site specific standards, the presampling preparation time can be deleted, allowing the EPA to mobilise to a totally new site and begin analysing unknowns the same day.

Samples were prepared for EDXRF analysis using the following method:

1. 25 grams of a homogenized sample were placed in a disposable plastic tray and dried in a microwave oven for three minutes.
2. The dried sample was passed through a 10 mesh sieve to remove large objects such as stones and metal fragments.
3. The sieved sample was ground in a clean glass mortar and pestle until it was a fine powder.
4. The ground sample was placed in a disposable plastic sample cup and covered with a .33 mm thick Kapton window film.
5. The sample location and depth were marked on the sample cup.

Fig 2. Toxic-Graphical Map (Cu)



Presentation of Results

Between October 31, 1989 and November 3, 1989 over 130 samples from 37 locations were obtained, prepared and analysed by the Spectra 6000. The analytical data were used to create toxic-graphical maps using the software package Surfer.[3] A toxic-graphical map is a contour diagram delineating a series of progressive iso-toxic lines representing uniform concentration. Two of these maps are presented in figures 2 & 3. The figures are plotted on a regular X,Y grid. The X axis has an east-west orientation while the y axis has a north-south orientation. The grid scale is in feet. The two figures are described as follows:

Approximately 180,000 square feet of this site is contaminated at the surface above the NJDEP guidelines for copper.

Figure 3

This figure depicts the extent of zinc (Zn) contamination at the surface. The iso-toxic lines range from 100 ppm to 4600 ppm with a 1000 ppm interval. Zinc contamination has not migrated as far away from the black ash pile as has copper. Approximately 80,000 square feet of the surface of the site has zinc contamination levels above the NJDEP guidelines.

Figure 2: This figure shows the Copper (Cu) contamination at the surface of Franklin Burn Site 1. The iso-toxic lines range from 100 ppm to 4600 ppm with a 1000 ppm interval between lines. The interior of the 4600 ppm ring contains the highest concentration of contamination. The horizontal extent of contamination can be clearly seen in this figure.

Fig 3. Toxic-Graphical Map (Zn)

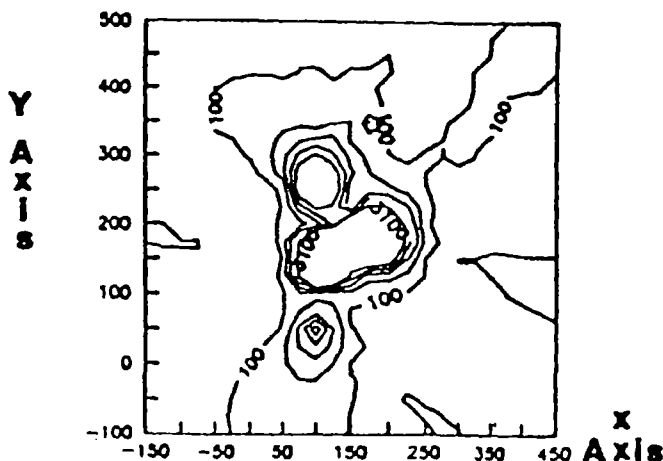


TABLE 4.

Element	Mean	Standard Deviation STD	Relative % Standard Deviation	True Value
Cu	532	34.95	4.69	609
Zn	4551	155.03	3.41	4760
Pb	6159	165.17	2.68	6550

Analytical Precision

To measure the precision of the EDXRF instrument, a known standard was run at the beginning of the day, the end of the day and once every ten unknowns. Over the four day period in which unknowns were analysed, the National Bureau of Standards (NBS) # 1648 was run a total of 21 times. Statistical analyses of the precision study results are presented in Table 4. The relative percent standard deviations were below 5 %. This indicates that the EDXRF was operating in a precise manner with little error due to machine variability.

Confirmation of Results

In order to ensure the accuracy of the results obtained from the Spectrace 6000, 1 out of every 10 samples was sent to a CLP laboratory for TCL Metals analyses. A total of 13 samples were sent. The metal concentrations ranged from a few ppm upwards to 100,000 ppm. Table 5 presents the comparative data of four samples. The CLP data was plotted against the EDXRF data for all 13 samples. A linear regression was then calculated for these plots. For the two analytical

methods to be considered equivalent the regression line must have a slope near unity and the correlation coefficient (R^2) should be greater than 0.90. Table 6 shows the regression data for Cu, Zn and Pb. Figures 4 and 5 show the regression plots for Cu and Zn. There are two lines plotted on each of these figures. The first line is for the ideal case when CLP = EDXRF. The second line is generated using the experimental regression data from Table 6.

Table 6

Element	Slope	Correlation Coefficient	Y Intercept
Cu	0.981	0.968	670.1
Zn	0.936	0.967	204.8
Pb	0.766	0.978	242.1

The slopes for two of the lines are close to unity and all of the correlation coefficients are greater than 0.96. This indicates agreement between the CLP and EDXRF

results. Therefore, the Tracer Spectrace 6000 can be used as an on-site screening device to delineate site boundaries and provide information on metal contamination comparable to CLP. The regression analysis could be improved if more sample points and more consistent sample concentration levels were used, however, this was beyond the scope of the project.

VII Conclusions

The primary objective of this sampling project, to define the extent and depth of contamination, has been met. As is clearly shown on the toxic-graphical maps, copper is the most widely spread contaminant and should be used as the criterion for determining site boundaries. The surface contamination is more extended than at depth. The maps also show that the contamination underneath the ash pile extends to a depth of 4 ft.

The secondary goal of this project was to investigate the feasibility of using on-site analytical methods. The analytical precision study demonstrates that the EDXRF was operating in a reliable manner. The relative percent standard deviation for Cu, Pb, and Zn are well within acceptable levels of variance. The regression analyses between the CLP and EDXRF results show that this

Table 5

Sample	Element	CLP	EDXRF
200,200-1 M88N-09	Cu	100,000	96,691
	Zn	18,600	26,048
	Pb	17,300	20,128
170,190-2 M88N-07	Cu	51,500	63,766
	Zn	12,600	10,259
	Pb	16,800	19,567
150,230-1 M88N-08	Cu	1,680	1,185
	Zn	327	386
	Pb	291	343
250,50 M88N-03	Cu	21	32
	Zn	7	2
	Pb	16	14

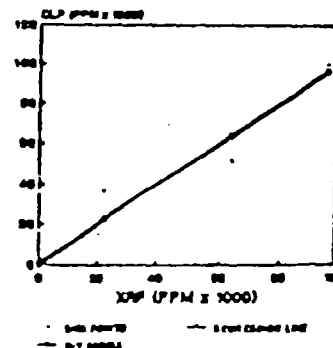
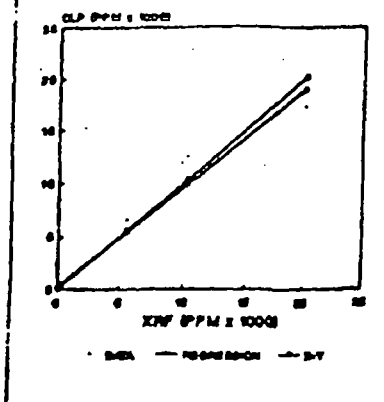
Figure 4.
CLP vs EDXRF (Cu)

Figure 5.
CLP vs EDXRF (Zn)



on-site analytical method is quantitatively comparable to the CLP results. For every sample which EDXRF showed as being above the NJDEP action guidelines, the CLP confirmed. This method also proved to be both cost effective and time saving. Using EDXRF saved the EPA \$19,200 on analysis costs. Analytical results were available the same day allowing the OSC to make time critical decisions. Had on-site EDXRF not been used, remediation definitely would have been required because surface contamination extended further than originally suspected or visually discernable. The EDXRF analyses showed this unexpected contamination and allowed additional samples to be collected and analysed until the contamination boundaries were found.

This on-site analytical method utilising this field mobile EDXRF technology is a viable tool available to the EPA for screening soil samples in order to determine heavy metal contamination.

Acknowledgements

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7/11/11

**APPLICATIONS OF X-RAY
FLUORESCENCE SPECTROSCOPY
FOR SITE SCREENING**

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Applications of X-ray Fluorescence Spectroscopy For Site Screening

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ABSTRACT

Recent field investigations have demonstrated the successful use of x-ray fluorescence spectroscopy (XRF) screening analysis for metal contamination at various hazardous waste sites.

Using minimal sample preparation and field sampling methods the results were comparable to laboratory results using conventional methods such as atomic absorption (AA) and inductively coupled plasma (ICP). Multi-elemental analysis was performed on soil samples with particular interest in lead, arsenic, chromium, copper, and zinc levels. Detection limits achieved for some elements were ten parts per million. The XRF results were used in mapping and contouring the extent of contamination of a hazardous waste site containing inorganic contamination.

The lower detection limits and quick turn around times proved the feasibility of the XRF in screening of hazardous waste sites and environmental monitoring.

INTRODUCTION

Ecology and Environment, Inc. (E&E, Inc.) Field Investigation Team was asked by the U.S. EPA to initiate a field analytical screening program to assist in site investigations and listing or expanded site investigations. Field screening is projected to enhance the pre-remedial program by assisting the U.S. EPA in completing the site inspection inventory in a timely manner, by decreasing the number of "non-detected" samples, by supporting the revised Hazardous Ranking System, and by accelerating remedial investigation and feasibility studies. The increased sampling capability increases the chances of detecting an

observed release without compromising data quality since rapid turn around allows Contract Laboratory confirmation.

Part of this program was to develop a screening analysis for metal contaminated solids such as soils and sediments studies, including mine tailings and mining waste materials in U.S. WPA Region VIII. E&E, Inc. determined the best instrumentation for these types of analyses would be an x-ray fluorescence spectrometer. Previous successful operations with XRF indicated the XRF's usefulness in screening analysis of metal contaminated solids on potential hazardous waste sites (1,2,3,4). However, lower detection limits were difficult to achieve.

The rapid turn around time available on a wide variety of elements and minimal sample preparation made the XRF almost ideal for screening analysis. As previously stated, one major drawback associated with the XRF was the relatively high detection limits. However, with the Tracor 6000 XRF, E&E, Inc. is able to achieve detection limits of approximately ten parts per million consistently and confidently, without liquid nitrogen cooling of the XRF detector as needed for other conventional low level XRF analysis. This advantage greatly increases the mobility of the instrument. These detection limits are more than adequate for most metal contaminated sites.

INSTRUMENT CALIBRATION

Elemental identification and quantitation is obtained using the "Fundamental Parameters" personal computer software in conjunction with the Tracor Spectrace 6000 energy dispersive x-ray fluorescence analyzer.

When metal atoms present in a soil sample (metals are actually present as metal complexes) are irradiated with a beam of x-rays, electrons in the atom's lower lying energy levels are excited to higher energy levels. The vacancies left in the inner electron orbitals make the atom unstable. Relaxation to the stable ground state occurs resulting in the emission of x-rays characteristic of the excited elements. Thus, by examining the energies of the x-rays emitted by the irradiated soil sample, identification of metals present in the sample is possible. Comparing the intensities of the x-rays emitted from a given unknown sample, to those emitted from reference standards with known analyte concentrations

allows quantitation of the metals present in the sample. During sample analysis a spectrum is acquired. Different instrumental parameters and excitation conditions are used to analyze for different metals. Generally, metals are segregated for analysis into groups which emit x-rays within a specified energy range. Currently, fourteen different elements are being analyzed using three separate excitation conditions. A sample spectrum for the mid atomic number elements potassium, calcium, and chromium is presented in Figure 1: *Tracor X-Ray Spectral Display Mid-Z Analysis*. Figure 2: *Tracor X-Ray Spectral Display High-Z Analysis* is a sample spectrum for the high atomic number elements: manganese, iron, copper, zinc, arsenic, and lead. And a sample spectrum for the elements silver, cadmium, tin and antimony are presented in Figure 3: *Tracor X-Ray Spectral Display Silver Analysis*.

As previously stated, a peak's position along the spectral energy axis (horizontal axis) is indicative of the element identification. It should be noted that each metal will exhibit several peaks in the spectrum, since a separate peak will be observed for each allowed electron orbital energy transition. For example, peak A in Figure 2 is lead's L-alpha line. It arises when electrons initially excited to a lead atom's M shell return to the lead atom's L shell giving off x-rays which have an energy of 10.5 KeV. Peak B is lead's L-beta line. When electrons in the lead atom energetically relax from the N shell to the L shell, X-rays at 12.6 KeV are emitted.

Prior to running a series of samples, the instrument is calibrated using a pure copper disk. Basically, the instrument adjusts its spectral energy axis until the copper x-ray emission peaks fall at the correct energies. The energies of the other metal peaks are then determined relative to the established copper peaks.

The area under each element's peaks, termed peak intensity, is proportional to the concentration of that element in a sample. Peak integration is carried out and the results evaluated using Tracor's "Fundamental Parameters" software.

Prior to running unknown samples, a set of reference standards with known and concentrations is run. Currently, certified samples are available from the U.S. National

TRACOR-XRAY SPECTRAL DISPLAY

SPECTRUM : NBS5 1 MID-Z ANALYSIS

TUBE VOLTAGE : 13 KV
TUBE CURRENT : 0.10 mA
ATMOSPHERE : AIR

FILTER USED : ALUMINUM
LIVETIME : 87 SEC

F.S. = 2K

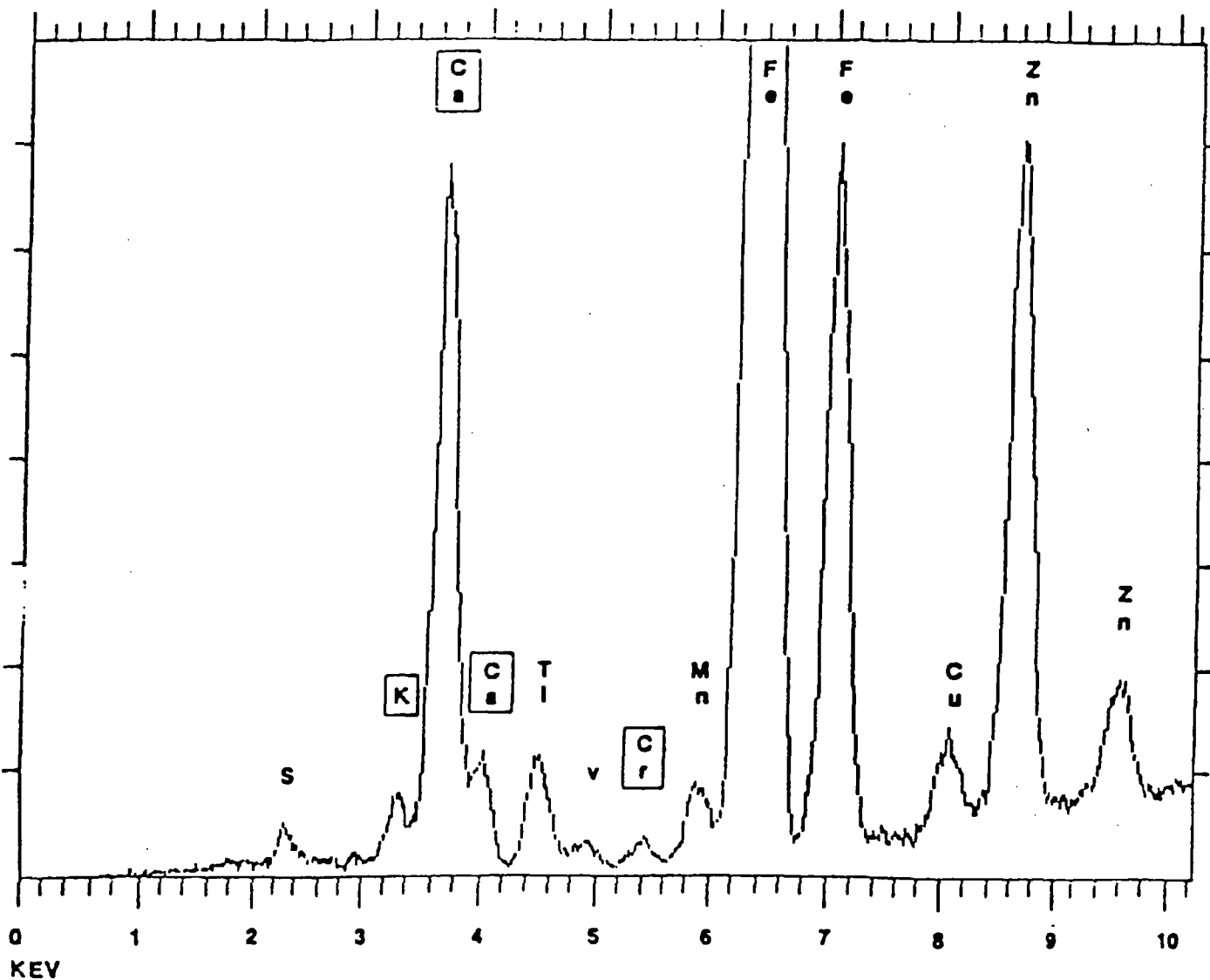


Figure 1

TRACOR-XRAY SPECTRAL DISPLAY

SPECTRUM : NBS2 1

HIGH Z ANALYSIS

TUBE VOLTAGE : 30 KV

TUBE CURRENT : 0.17 mA

ATMOSPHERE : AIR

FILTER USED : FIVE

LIVETIME : 173 SEC

F.S. = 8K

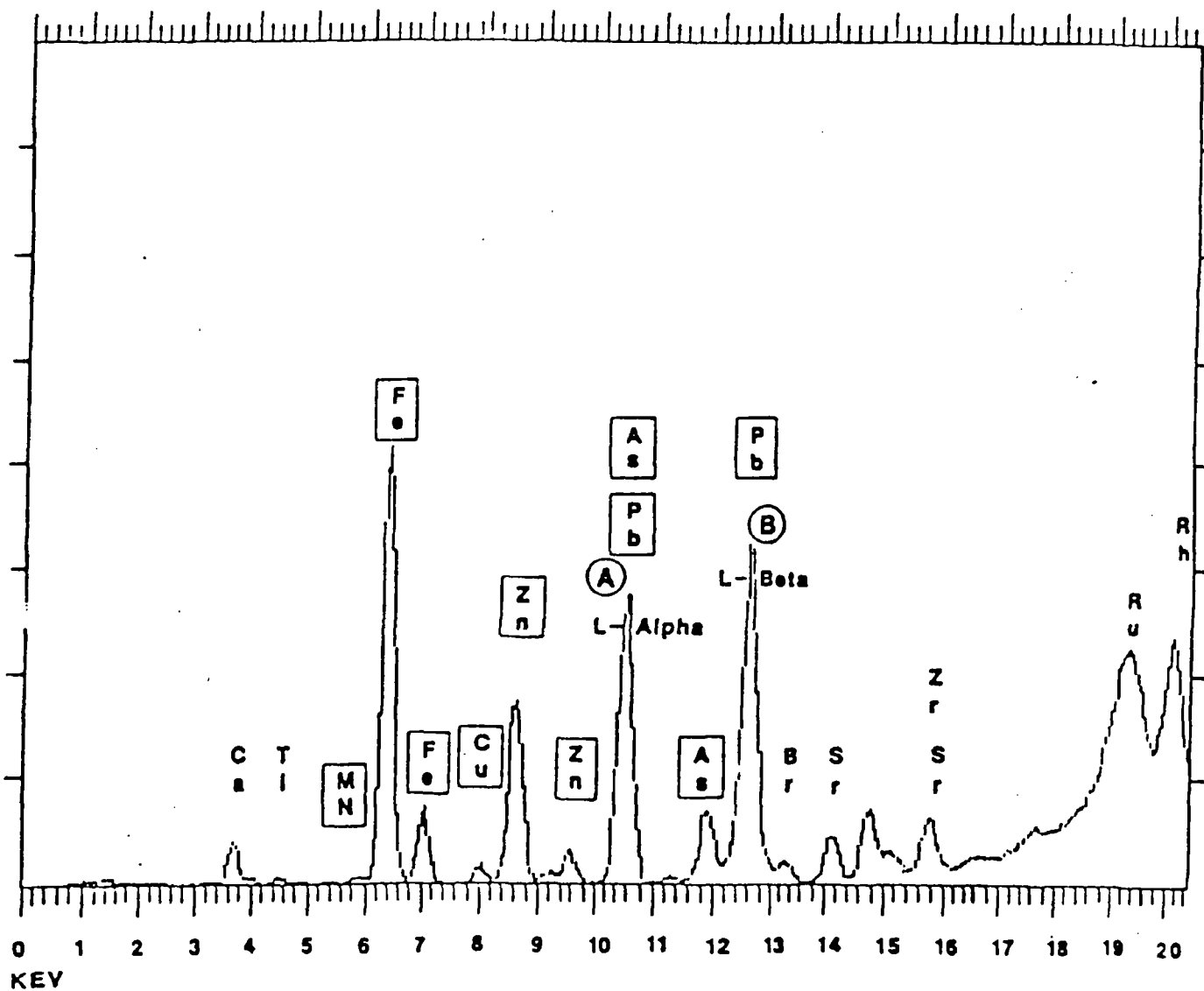


Figure 2

TRACOR-XRAY SPECTRAL DISPLAY

SPECTRUM : NBS2 1 SILVER ANALYSIS

TUBE VOLTAGE : 50 KV
TUBE CURRENT : 0.35 mA
ATMOSPHERE : AIR

FILTER USED : ALUMINUM
LIVETIME : 135 SEC

F.S. = 256

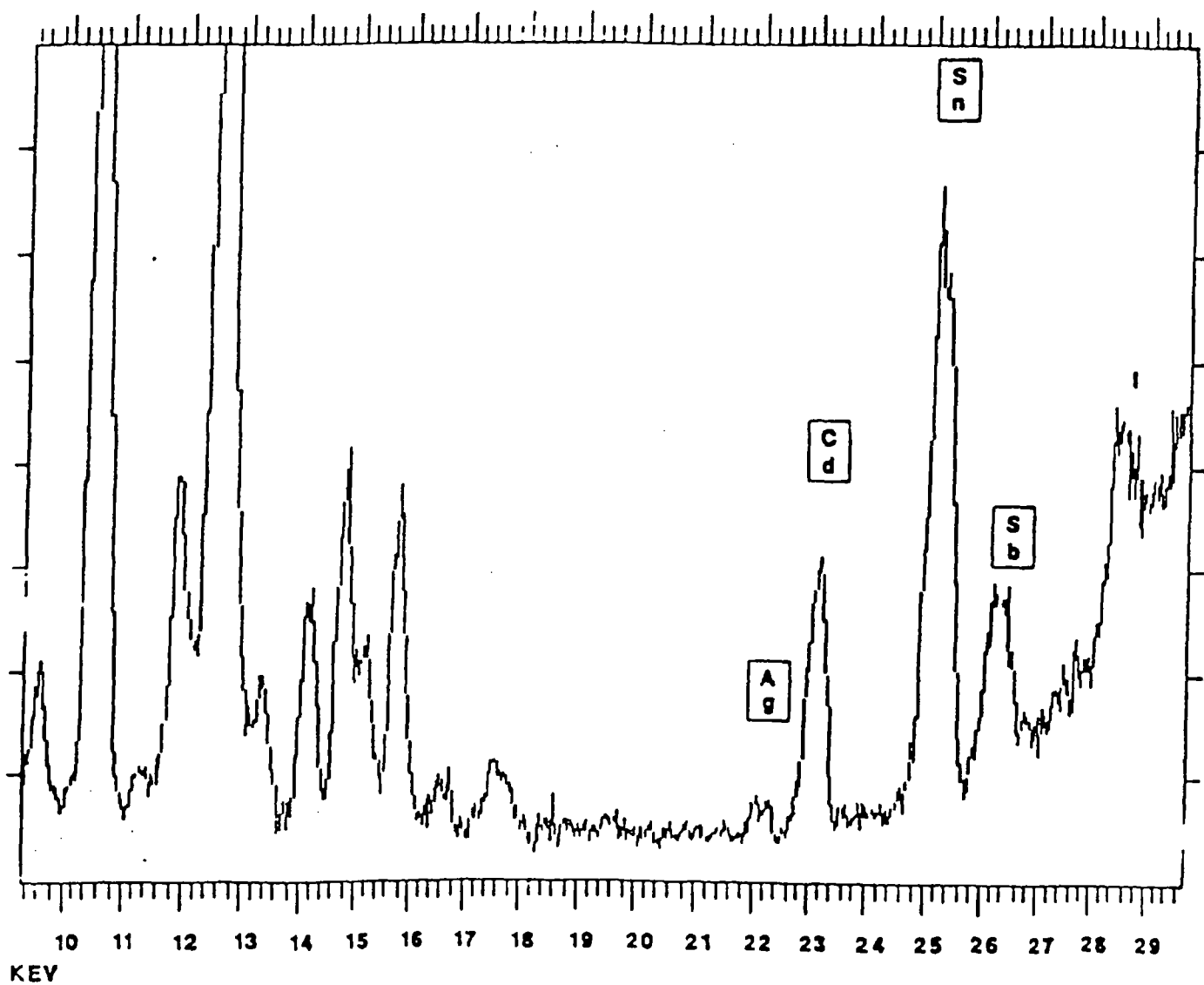


Figure 3

Bureau of Standards and the Canadian Department of Energy, Mines and Resources. In a typical XRF analysis the standards are used to construct a calibration curve by plotting measured x-ray intensities against known concentrations. However, in soil sample analysis, the varied composition of the soils causes problems that can attenuate the emissions from elements being analyzed. In general, the absorbing properties of a soil matrix, termed matrix effects, increase as a function of the average number of the elements in the sample increase. In addition to matrix effects, inter-element effects are also present.

Inter-element effects occur when an element in the matrix can specifically absorb or enhance x-ray photons emitted from another element. The "Fundamental Parameters" program quantitatively corrects for changes in the sample's matrix and for inter-element effects. The program mathematically produces theoretical standards to account for sample matrix variations, thereby allowing for quantitative analysis with minimum standards.

During standardization, the program reads a standards file which contains known concentrations of the elements in the sample to be used as a standard. Next, theoretical sensitivities called "pure element count rate" values are calculated from measurements of pure elemental standards or well characterized reference materials. Pure element count rates represent the sensitivity of the instrument for the elements to be analyzed. Elements which are close in atomic number have similar sensitivities.

Finally, the program calculates values termed alpha coefficients which quantitatively describe matrix absorption, or enhancement effects on the analyte intensity. The alphas are calculated using the hypothetical standards established by the "Fundamental Parameters" program. The program first generates a list of standards with concentrations of the actual standards. For each of the hypothetical standards, the program calculates the relative intensities that would be measured for each element in the standard. Alpha coefficients are then calculated from these hypothetical standards. The standards data are stored on a disk and the instrument does not have to be standardized prior to each run, only reference calibrated with the pure copper standard.

When running an unknown, the program first recalculates pure element count rates

by sorting the standards to which one is closest to the unknown based on the intensities of the unknowns and standards. Analysis of unknowns proceeds by an iterative computation. An estimate of the composition of the unknown is made by comparison of the measured intensities to the pure element count rate values. The estimated concentrations are then used along with the alpha coefficients to make a new estimate of the composition. The process is repeated again with the alpha coefficients and pure elemental count rates to calculate a new composition. If the difference between the last calculated concentration and the concentration determined from the new iteration is less than one percent relative, the program assumes convergence and the analysis procedure ends.

SAMPLE PREPARATION

Soil and sediment samples are collected with the usual protocol, although not as large a sample is required as with the acid digestion in AA/ICP analysis. The most homogeneous sample possible is recommended.

No great differences have appeared as whether grab or composite sampling is more suitable provided the samples are well mixed. Grab samples have shown a slight statistical advantage in comparing with AA/ICP results which probably reflect sample homogeneity.

Analysis of particulates collected on dust filters is just now being tested. No sample preparation is involved with air filters, however, accuracy of the results depends greatly on sampling procedures and accurate measurement of sample amount.

Sample preparation for XRF screening analysis was designed to be kept simple. Accuracy of XRF results is described in detail by Wheeler, 1987 (5). The sample preparation is minimal to ensure rapid turn around in addition to providing adequate analytical quality. The minimum sample preparation includes air or mild oven drying of the solid sample and mixing in a mortar and pestle to homogenize the sample as much as possible. No sieving is necessary unless the sample contains particles larger than ten mesh. After mixing, the sample is placed as a loose powder in a sample cup and sealed with mylar. The sample is irradiated through the mylar by the instrument and analyzed.

Using this procedure, a sample can be prepared and analyzed in approximately thirty minutes.

Sensitivity of the XRF is proportional to the fineness of the sample and smoothness of the analytical surface. Procedures not employed by E&E, Inc., but which improve analytical sensitivity include grinding the sample and pressing a pellet or fluxing the sample. Both methods have been deemed inappropriate for site screening analysis. These procedures, however, are still obviously quicker and less hazardous than the acid digestion AA/ICP methods.

QUALITY ASSURANCE AND CONTROL

Quality assurance and control for XRF screening analysis includes duplicate sample, standards checks, and splits with other laboratories. Sample duplicates are run at a ten to twenty percent frequency with the sample split preparation. This indicates the precision of an analysis and sampling procedure as well as the homogeneity of the sample matrix.

An indication of the precision of the Tracor 6000 XRF alone was made by analyzing a standard as an unknown ten times and calculating the standard deviation (Table 1: Standard Deviation of Ten NBS Standard Sample Runs.)

Standards used to calibrate the Tracor 6000 XRF were obtained from the National Bureau of Standards (NBS) and the Canadian Department of Energy, Mines and Resources (CDEMR). These standards are run at a ten to twenty percent frequency during a site analysis to determine continuing calibration of the instrument. The NBS and CDEMR certified standard results were compared to results obtained from analyzing these standards as unknowns on the XRF (Table 2: Comparison of XRF Results to NBS and Canadian Standards.). The Tracor 6000 results compared favorably to the certified standard results, especially for lead. To date, in samples containing high lead concentrations, arsenic percentages lower than approximately twelve percent of the lead concentrations could not be detected (Table 3: Arsenic Detection Limits for Increasing Lead Concentration). In addition, potassium and manganese values were observed to be increasingly biased low with increasing calcium and iron concentrations, respectively.

COMPARISON OF XRF RESULTS TO CONTRACT LABORATORY PROGRAM DATA

As in any comparison, the more similar the sample and the procedure, the closer the comparison will become. In dealing with soils and solid environmental samples the homogeneity of the matrix is questionable and therefore a true duplicate or split is difficult to achieve. Also, the differences in the methodologies of the XRF and Contract laboratory program (CLP) AA/ICP analysis lead to the differences observed in the comparison results.

A comparison between XRF and CLP results for a specific site is reported in Table 4: Comparison of XRF Results to CLP Results. Flags for the CLP data were not available at the time this manuscript was prepared. In most cases, XRF values were consistently high in comparison to CLP results for this site. Similar comparisons from other sites have yielded different results due to variations in soil matrices and CLP laboratories. In most XRF/CLP comparisons of data, chromium tends to be consistently higher in the XRF results by approximately two times. No apparent reason is known for this phenomenon, but some theories suggest loss of chromium in the acid digestion process through a change in the oxidation number or enhancement properties in the soil matrix when XRF analysis is performed. Nevertheless, XRF results compared favorably with CLP results in many cases and certainly justify the XRF as a site screening tool.

APPLICATIONS OF RESULTS

Interpretation of XRF results have been used most successfully in more fully characterizing the extent and magnitude of contaminants and supporting health assessment studies, and aiding in remedial action by confirming extent of clean-up. XRF results have also been used for field screening purposes which have aided in preliminary evaluations and onsite decision making. The quick turn around times and low detection limits achieved by the XRF unit make this instrument ideal for these and many more applications.

Sampling points and grid layouts have also been used extensively in interpretation of XRF results. Grid layouts are based on size of site, detail of investigation, turn around time required, and economics such as extent of sampling and man hours available. Results

TABLE 1
STANDARD DEVIATION OF TEN NBS STANDARD & SRM 1648 SAMPLE RUNS

ELEMENT	RUN 1 (PPM)	RUN 2 (PPM)	RUN 3 (PPM)	RUN 4 (PPM)	RUN 5 (PPM)	RUN 6 (PPM)
K	10520	10090	9220	10150	9840	9080
CA	52220	51630	50500	51790	50550	50870
CR	370	370	360	360	370	360
MN	700	680	660	800	830	760
FE	25780	26040	25810	25800	25540	25350
CU	550	630	580	550	570	540
ZN	4370	4340	4400	4340	4350	4260
AS	0	0	0	0	0	0
PB	6070	6050	6020	6050	6060	5920
AG	10	10	0	10	0	10
CD	80	80	70	80	70	70
SN	170	170	170	170	170	160
SB	40	40	30	40	40	40

ELEMENT	RUN 7 (PPM)	RUN 8 (PPM)	RUN 9 (PPM)	RUN 10 (PPM)	AVERAGE (PPM)	STANDARD DEVIATION
K	9830	9880	9350	9190	9715	457.3
CA	51320	50770	50180	51250	51108	612.6
CR	360	340	370	360	362	8.7
MN	610	740	740	810	733	67.1
FE	25500	25360	25590	25860	25663	217.2
CU	550	550	550	550	562	25.2
ZN	4270	4290	4310	4310	4324	42.0
AS	0	0	0	0	0	0.0
PB	5940	6010	5960	5940	6002	54.0
AG	10	0	0	0	5	5.0
CD	80	70	70	80	75	5.0
SN	170	170	170	170	169	3.0
SB	40	40	30	40	38	4.0

TABLE 2
COMPARISON OF XRF RESULTS TO NBS AND CANADIAN STANDARDS

SAMPLE	ELEMENT	CONCENTRATION (PPM)		RELATIVE PERCENT DIFFERENCE (%RPD)
		UNKNOWN	TRUE	
NBS #SRM 1648 SOIL STANDARD	K	9833	10500	6.56
	CA	51817	NA	NA
	CR	387	403	4.05
	MN	700	860	20.51
	FE	26213	30100	13.80
	CU	570	609	6.62
	ZN	4420	4760	7.41
	AS	ND	115	NA
	PB	6073	6550	7.56
	AG	ND	6	NA
	CD	83	75	18.18
	SN	170	NA	NA
	SB	40	NA	NA
SO-3 CANADIAN SOIL STANDARD	K	9010	11600	25.13
	CA	140010	146300	4.39
	CR	40	26	42.42
	MN	280	520	60.00
	FE	12790	15100	16.57
	CU	20	17	16.22
	ZN	50	52	3.92
	AS	ND	NA	NA
	PB	30	14	72.73
	AG	ND	NA	NA
	CD	ND	NA	NA
	SN	10	NA	NA
	SB	ND	NA	NA
TCU-1A CANADIAN OIL STANDARD	K	ND	NA	NA
	CA	2350	2500	6.19
	CR	60	NA	NA
	MN	430	NA	NA
	FE	272770	304700	11.06
	CU	226670	267800	16.64
	ZN	25220	28600	12.56
	AS	ND	53	NA
	PB	3120	3640	15.38
	AG	120	145	18.87
	CD	240	96	85.71
	SN	110	NA	NA
	SB	10	NA	NA

ND - NOT DETECTED

NA - NOT ANALYZED

%RPD = $|X-Y|/((X+Y)/2)*100$, where
X = TRUE ; and Y = UNKNOWN

TABLE 2 (CONT.)
COMPARISON OF XRF RESULTS TO NBS AND CANADIAN STANDARDS

SAMPLE	ELEMENT	CONCENTRATION (PPM)		RELATIVE PERCENT DIFFERENCE (%RPD)
		UNKNOWN	TRUE	
PD-1 CANADIAN SOIL STANDARD	K	1780	NA	NA
	CA	4060	NA	NA
	CR	190	NA	NA
	MN	2050	NA	NA
	FE	205710	NA	NA
	CU	106570	NA	NA
	ZN	523810	NA	NA
	AS	7030	7700	9.10
	PB	24840	27500	10.16
	AG	130	NA	NA
	CD	2840	NA	NA
	SN	500	NA	NA
	SB	123	NA	NA
CPB-1 CANADIAN SOIL STANDARD	K	ND	NA	NA
	CA	8000	NA	NA
	CR	110	NA	NA
	MN	400	390	2.53
	FE	98370	84300	15.40
	CU	2720	2540	6.84
	ZN	45660	44200	3.25
	AS	ND	560	NA
	PB	669910	647400	3.42
	AG	680	626	8.27
	CD	800	143	139.34
	SN	190	190	0.00
	SB	3800	3600	5.41
SO-1 CANADIAN SOIL STANDARD	K	26660	26800	0.52
	CA	17640	18000	2.02
	CR	170	160	6.06
	MN	910	890	2.22
	FE	52180	60000	13.94
	CU	80	61	26.95
	ZN	130	146	11.59
	AS	ND	NA	NA
	PB	20	21	4.88
	AG	ND	NA	NA
	CD	ND	NA	NA
	SN	20	NA	NA
	SB	ND	NA	NA

ND - NOT DETECTED

NA - NOT ANALYZED

%RPD = $|X-Y|/((X+Y)/2)*100$, where
X = TRUE ; and Y = UNKNOWN

TABLE 2 (CONT.)
COMPARISON OF XRF RESULTS TO NBS AND CANADIAN STANDARDS

SAMPLE	ELEMENT	CONCENTRATION (PPM)		RELATIVE PERCENT DIFFERENCE (%RPD)
		UNKNOWN	TRUE	
KC-1A CANADIAN SOIL STANDARD	K	ND	NA	NA
	CA	390	NA	NA
	CR	50	NA	NA
	MN	80	100	22.22
	FE	113380	109000	3.94
	CU	6780	6290	7.50
	ZN	337000	346500	2.78
	AS	ND	NA	NA
	PB	22000	22400	1.80
	AG	1610	1720	6.61
	CD	3940	NA	NA
	SN	6020	6100	1.32
	SB	80	NA	NA
UM-1 CANADIAN SOIL STANDARD	K	ND	200	NA
	CA	16260	16700	2.67
	CR	3100	3100	0.00
	MN	900	1200	28.57
	FE	119140	134000	11.74
	CU	3770	4300	13.14
	ZN	100	100	0.00
	AS	ND	NA	NA
	PB	20	NA	NA
	AG	ND	NA	NA
	CD	10	NA	NA
	SN	20	NA	NA
	SB	ND	NA	NA

ND - NOT DETECTED

NA - NOT ANALYZED

%RPD = $|X-Y|/((X+Y)/2)*100$, where
X = TRUE ; and Y = UNKNOWN

TABLE 3
ARSENIC DETECTION LIMITS FOR INCREASING LEAD CONCENTRATIONS

SAMPLE	ELEMENT	CONCENTRATION (PPM)		PERCENT TRUE	RELATIVE PERCENT DIFFERENCE (%RPD)
		XRF	TRUE	AS TO PB	
SO-1 CANADIAN SOIL STANDARD	PB	20	21.0		4.88
	AS	ND	NA	NA	NA
SO-3 CANADIAN SOIL STANDARD	PB	30	14.0		72.73
	AS	ND	NA	NA	NA
SO-5 SAMPLE	PB	40.00	18.40		73.97
	AS	ND	1.90	10.33	NA
OP-1 SAMPLE	PB	90.00	18.60		131.49
	AS	ND	2.30	12.37	NA
SO-1 SAMPLE	PB	120	28.3		123.67
	AS	ND	3.4	12.01	NA
SO-4 SAMPLE	PB	170.00	60.70		94.76
	AS	20.00	24.60	40.53	20.63
SO-3 SAMPLE	PB	560	474.00		16.63
	AS	ND	2.70	0.57	NA
CCU-1A CANADIAN SOIL STANDARD	PB	3120	3640.0		15.38
	AS	ND	53.0	1.46	NA
NBS #SRM 1648 SOIL STANDARD	PB	6073	6550.0		7.56
	AS	ND	115.0	1.76	NA
SO-2 SAMPLE	PB	6820	8230.00		18.74
	AS	ND	11.90	0.14	NA
YC-1A CANADIAN SOIL STANDARD	PB	22000	22400.0		1.8
	AS	ND	NA	NA	NA
PD-1 CANADIAN SOIL STANDARD	PB	24840	27500.0		10.16
	AS	7030	7700.0	28.00	9.1
CPB-1 CANADIAN SOIL STANDARD	PB	669910	647400.0		3.42
	AS	ND	560.0	0.09	NA

ND = NOT DETECTED

NA = NOT ANALYSED

%RPD = $|X-Y|/((X+Y)/2)*100$

where X = XRF, and Y = TRUE

TABLE 4
COMPARISON OF XRF RESULTS TO CLP RESULTS

SAMPLE	ELEMENT	CONCENTRATION (PPM)		RELATIVE PERCENT DIFFERENCE (%RPD)
		XRF	CLP	
SO-1	K	32060	6380.0	133.61
	CA	9150	1970.0	129.14
	CR	330	40.7	156.08
	MN	870	417.0	70.40
	FE	42910	28800.0	39.35
	CU	90	33.0	92.68
	ZN	360	170.0	71.70
	AS	ND	3.4	NA
	PB	120	28.3	123.67
	AG	10	ND	NA
	CD	10	3.7	91.97
	SB	ND	4.7	NA
SO-2	K	35870	8310	124.76
	CA	6760	2440	93.91
	CR	300	58	134.91
	MN	540	455	17.09
	FE	56150	35800	44.26
	CU	80	31	87.77
	ZN	300	210.0	35.29
	AS	ND	11.9	NA
	PB	6820	8230.0	18.74
	AG	ND	ND	NA
	CD	10	1.9	NA
	SB	50	38.4	26.24
SO-3	K	33870	8540.0	119.45
	CA	9240	3690.0	85.85
	CR	350	72.3	131.52
	MN	980	1560.0	45.67
	FE	48530	49400.0	1.78
	CU	100	94.3	5.87
	ZN	570	308.0	59.68
	AS	ND	13.1	NA
	PB	560	474.0	16.63
	AG	ND	2.7	NA
	CD	ND	1.3	NA
	SB	ND	9.2	NA

ND - NOT DETECTED

NA - NOT ANALYZED

%RPD = $|X-Y|/((X+Y)/2)*100$, where
X = CLP ; and Y = XRF

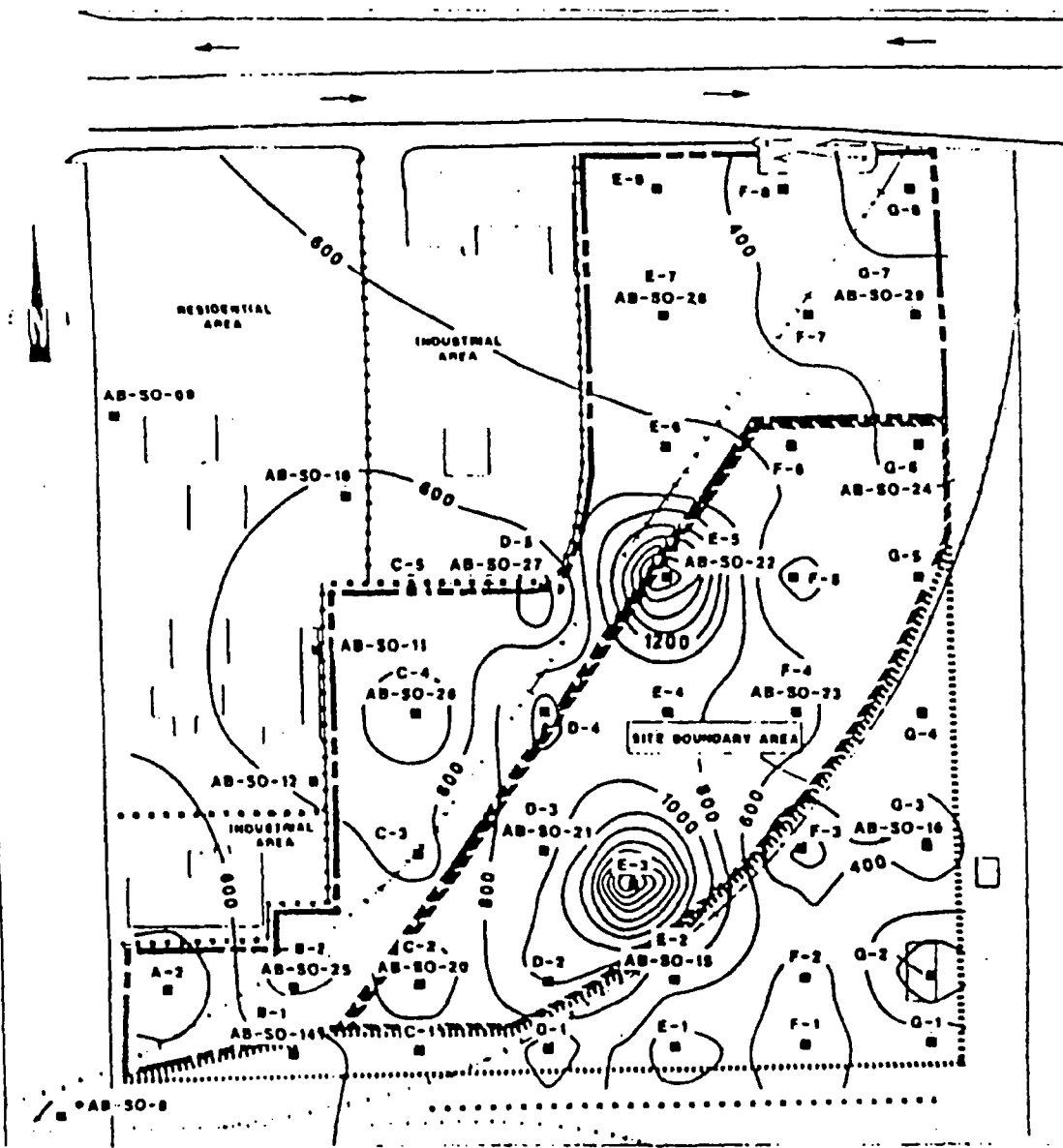
TABLE 4 (CONT.)
COMPARISON OF XRF RESULTS TO CLP RESULTS

SAMPLE	ELEMENT	CONCENTRATION (PPM)		RELATIVE PERCENT DIFFERENCE (%RPD)
		XRF	CLP	
SO-4	K	35210	5710.0	144.18
	CA	10050	4310.0	79.94
	CR	320	30.8	164.88
	MN	690	533.0	25.67
	FE	39380	22400.0	54.97
	CU	40	17.0	80.70
	ZN	160	102.0	44.27
	AS	20	24.6	20.63
	PB	170	60.7	94.76
	AG	ND	1.1	NA
	CD	ND	0.7	NA
	SB	ND	4.7	NA
SO-5	K	32190	6590.0	132.03
	CA	8360	1780.0	129.78
	CR	340	42.4	155.65
	MN	760	396.0	62.98
	FE	45280	27700.0	48.18
	CU	50	19.7	86.94
	ZN	120	84.0	35.29
	AS	ND	1.9	NA
	PB	40	18.4	73.97
	AG	ND	ND	NA
	CD	ND	ND	NA
	SB	ND	11.1	NA
OP-1	K	30070	7020.0	124.29
	CA	7900	1530.0	135.10
	CR	290	46.5	144.73
	MN	740	420.0	55.17
	FE	44460	34000.0	26.66
	CU	110	36.4	100.55
	ZN	210	142.0	38.64
	AS	ND	2.3	NA
	PB	90	18.6	131.49
	AG	30	ND	NA
	CD	10	0.4	184.62
	SB	ND	6.4	NA

ND - NOT DETECTED

NA - NOT ANALYZED

%RPD = $|X-Y| / ((X+Y)/2) * 100$, where
X = CLP ; and Y = XRF



LEGEND

--- Site boundary area

■ Soil sample
 ■ SW sample area

0 10 20
 Feet

FIELD INVESTIGATIONS OF UNCONTROLLED
 HAZARDOUS WASTE SITES
 Issue 0001 to 1000 & P 4

Title:

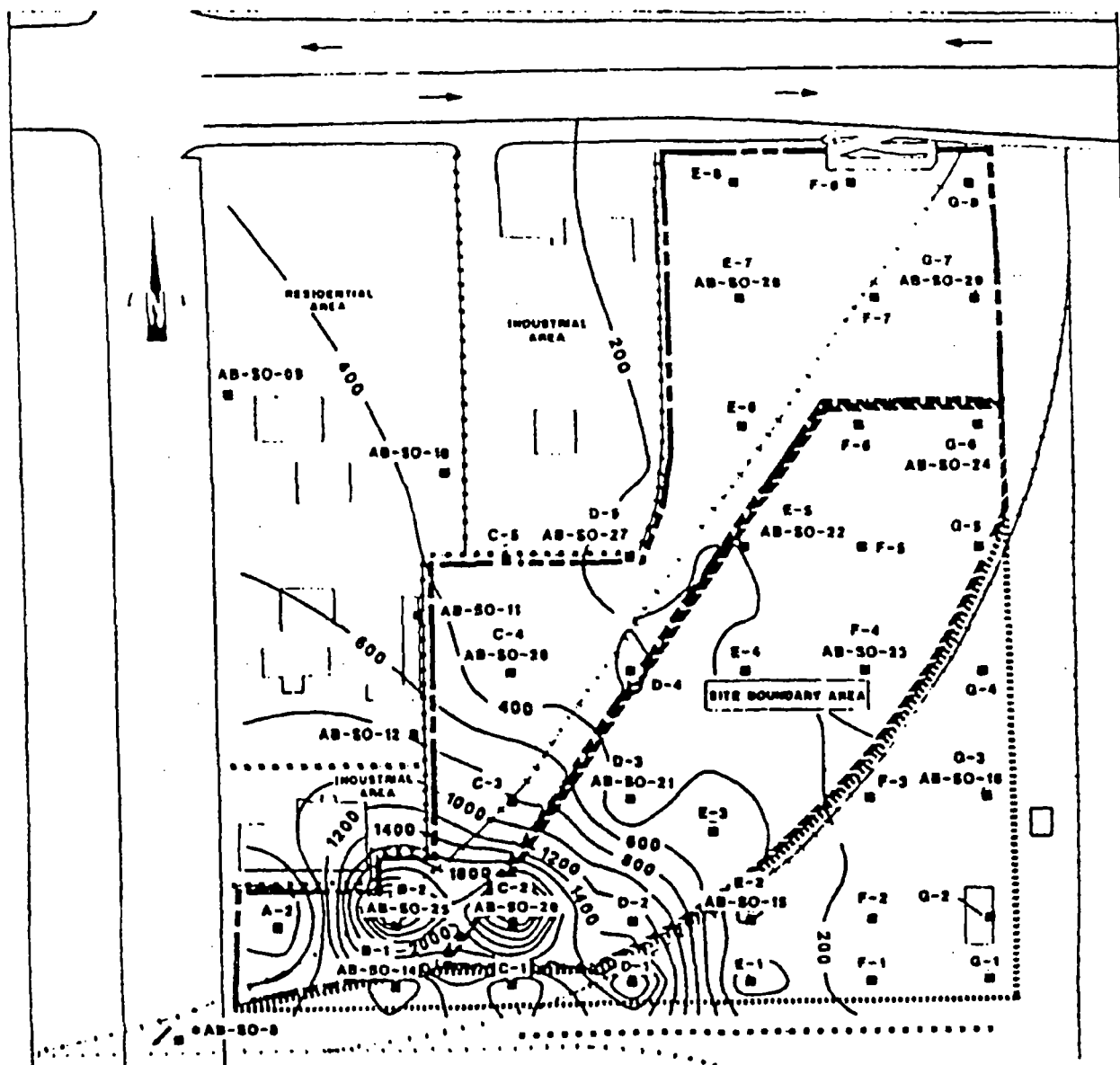
LEAD CONTOUR MAP

Contour Interval: 200 ppm
 100 200 300 400

Perdue & Associates, Inc.
 DENVER, COLORADO

FIG. 1

Date: 02/88 Drawn by: RSM



LEGEND

--- Site boundary area

■ Soil sample

□ 100' sample area

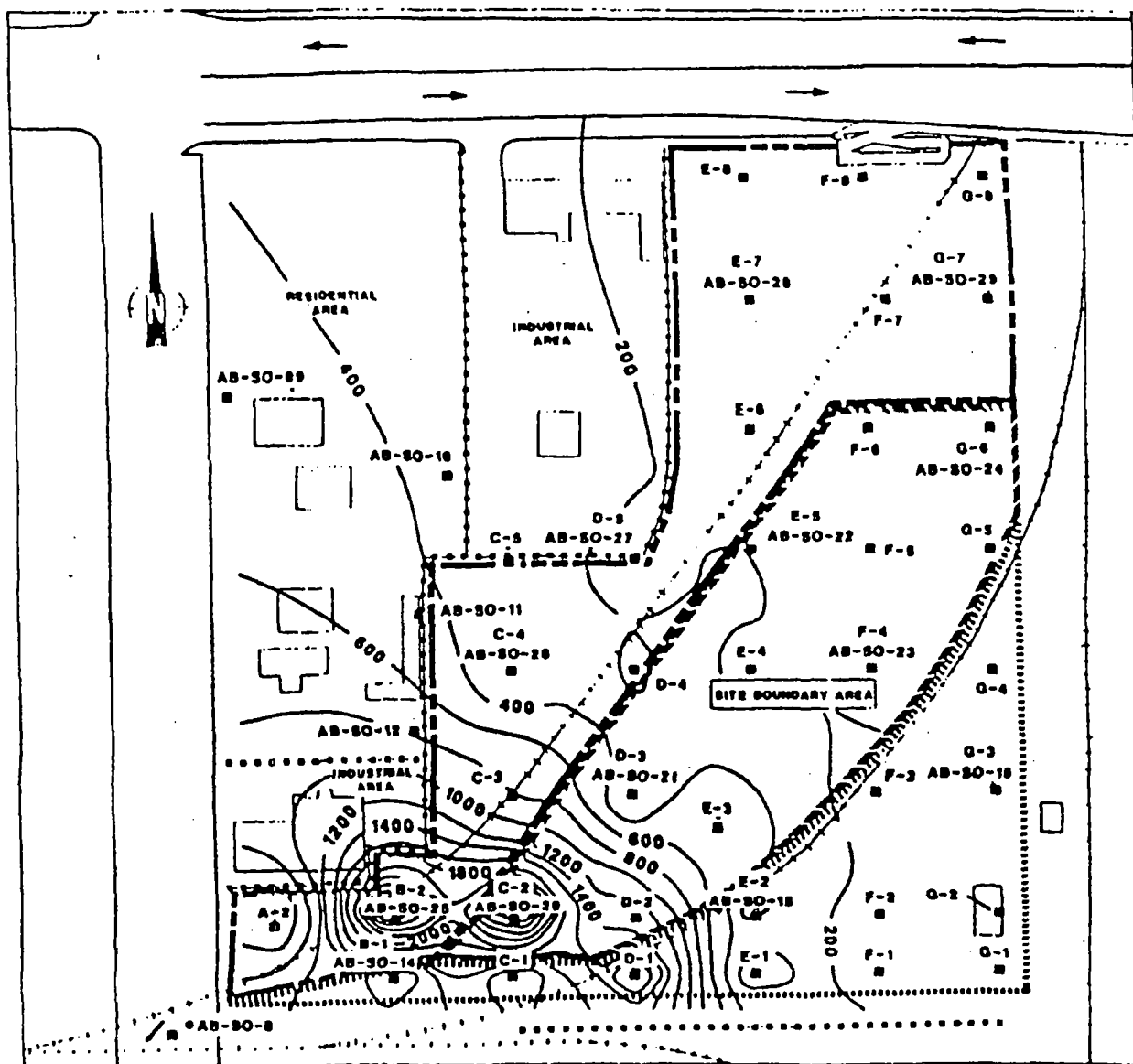
0 100 200

Feet

FIELD INVESTIGATIONS OF UNCONTROLLED HAZARDOUS WASTE SITES	
1000 REPORT TO THE D.P.C.	
DATE:	
ZINC CONTOUR MAP	
Contour Interval: 200 ppm	
100 769-6697-00	
ecology & environment, inc	FIG 1
DENVER, COLORADO	
Date: 8/88	Drawn by: ASM

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LEGEND

--- Site boundary area

■ Soil sample
 ■ SW sample sites

0 50 100
 Feet

FIELD INVESTIGATIONS OF UNCONTROLLED
 HAZARDOUS WASTE SITES
 THIS REPORT IS FOR EPA

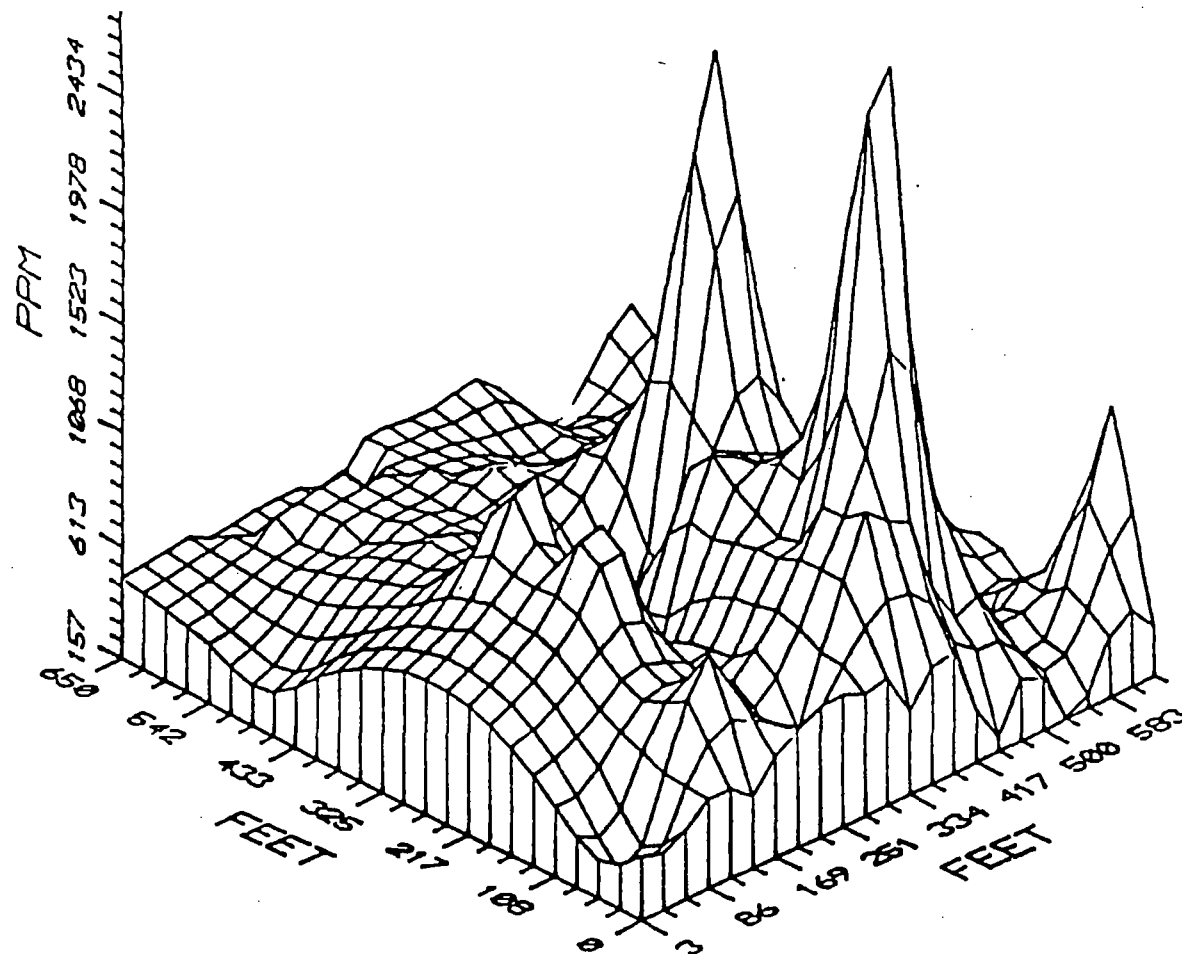
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 Contour Interval: 200 ppm
 100 100-0007-00

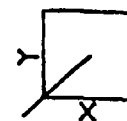
Ecology & Environment, Inc.
 DENVER, COLORADO

Date: 8/88 Drawn by: RSM Date:

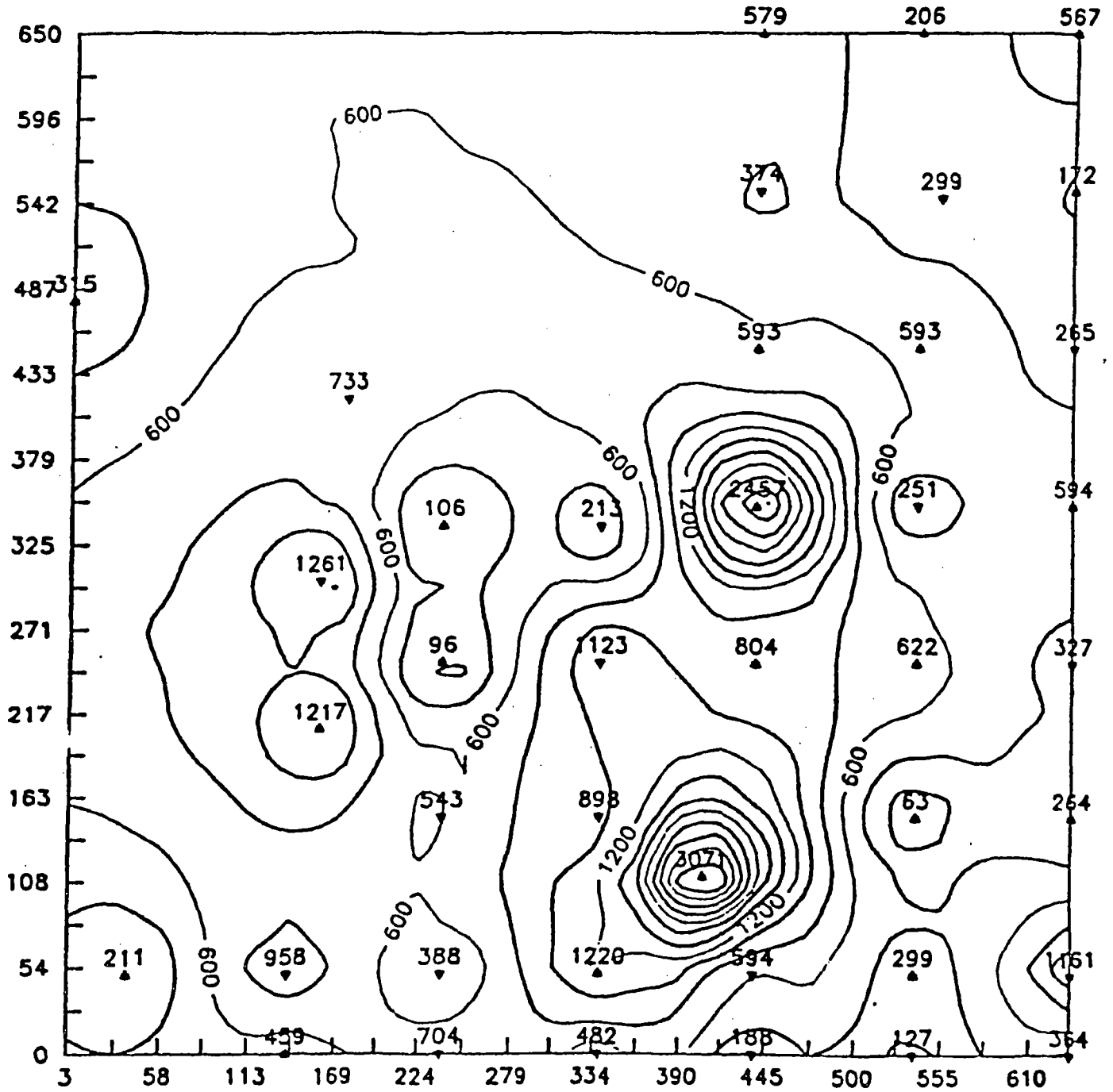
FIG. 1

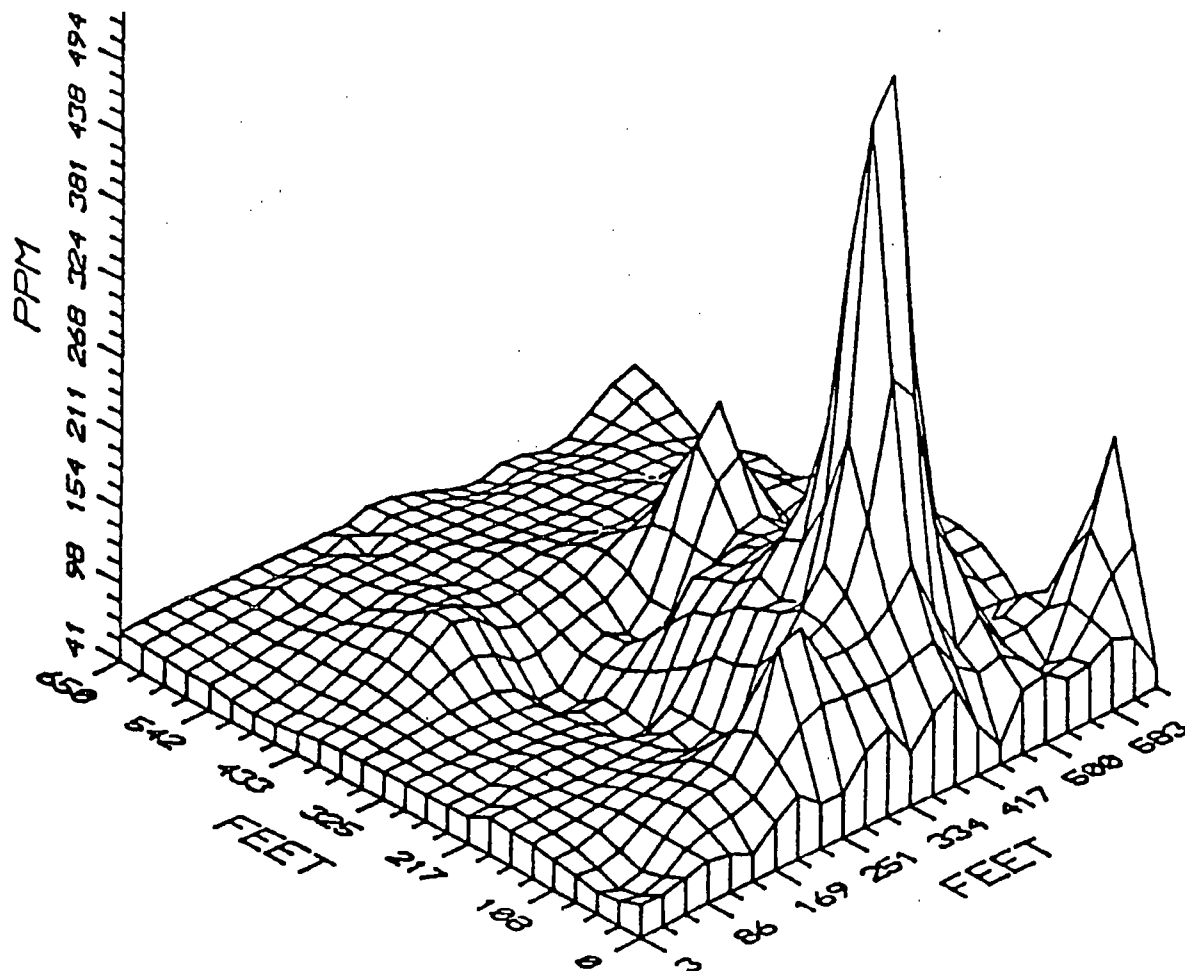


3-D LEAD CONTOUR



LEAD CONTOUR





3-D CHROMIUM CONTOUR

